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Vokes et al.

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(54) **METHODS AND SYSTEMS FOR DETECTING SUSPICIOUS OR NON-SUSPICIOUS ACTIVITIES INVOLVING A MOBILE DEVICE USE**

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G06Q 20/32 (2012.01)
G06F 21/31 (2013.01)

(52) **U.S. Cl.**

CPC **G06Q 20/40145** (2013.01); **G06F 21/316** (2013.01); **G06Q 20/3224** (2013.01); **G06Q 20/4016** (2013.01)

(58) **Field of Classification Search**

CPC G06Q 20/40145; G06Q 20/3224; G06Q 20/4016; G06F 21/316

See application file for complete search history.

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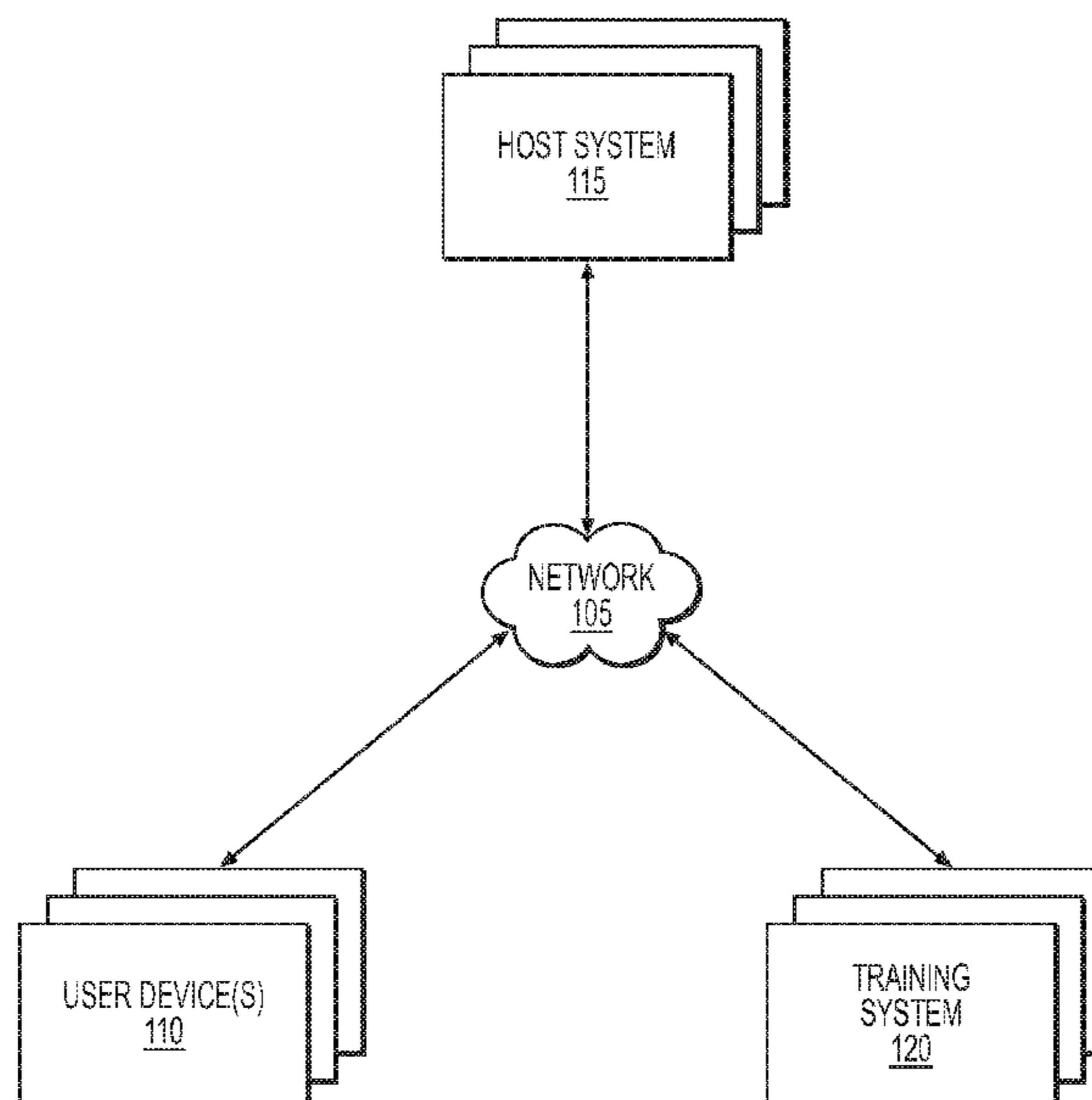
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(57) **ABSTRACT**

Systems and methods are disclosed for detecting a suspicious and/or a non-suspicious activity during an electronic transaction performed by a user device. One method comprises identifying, by a monitoring and detection component, a starting check point in the electronic transaction. The monitoring and detection component may then receive contextual data from one or more sensors of the user device. Based on the contextual data and a machine learning model, the monitoring and detection component may determine whether an expected behavior occurred. Entry of user credentials may be enabled in response to determining that the expected behavior occurred, whereas the electronic transaction may be terminated in response to determining that the expected behavior did not occur.

20 Claims, 13 Drawing Sheets



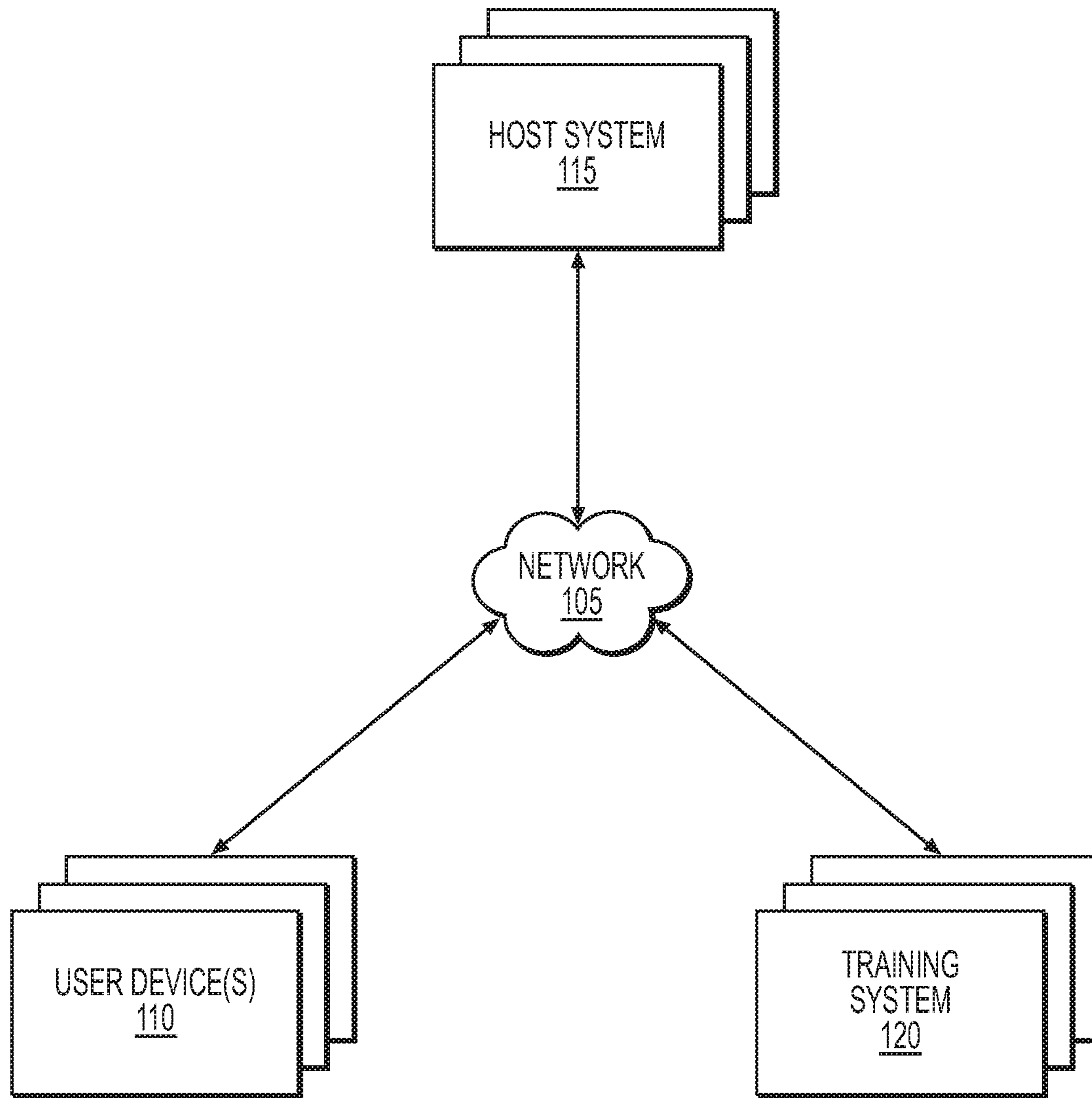


FIG. 1

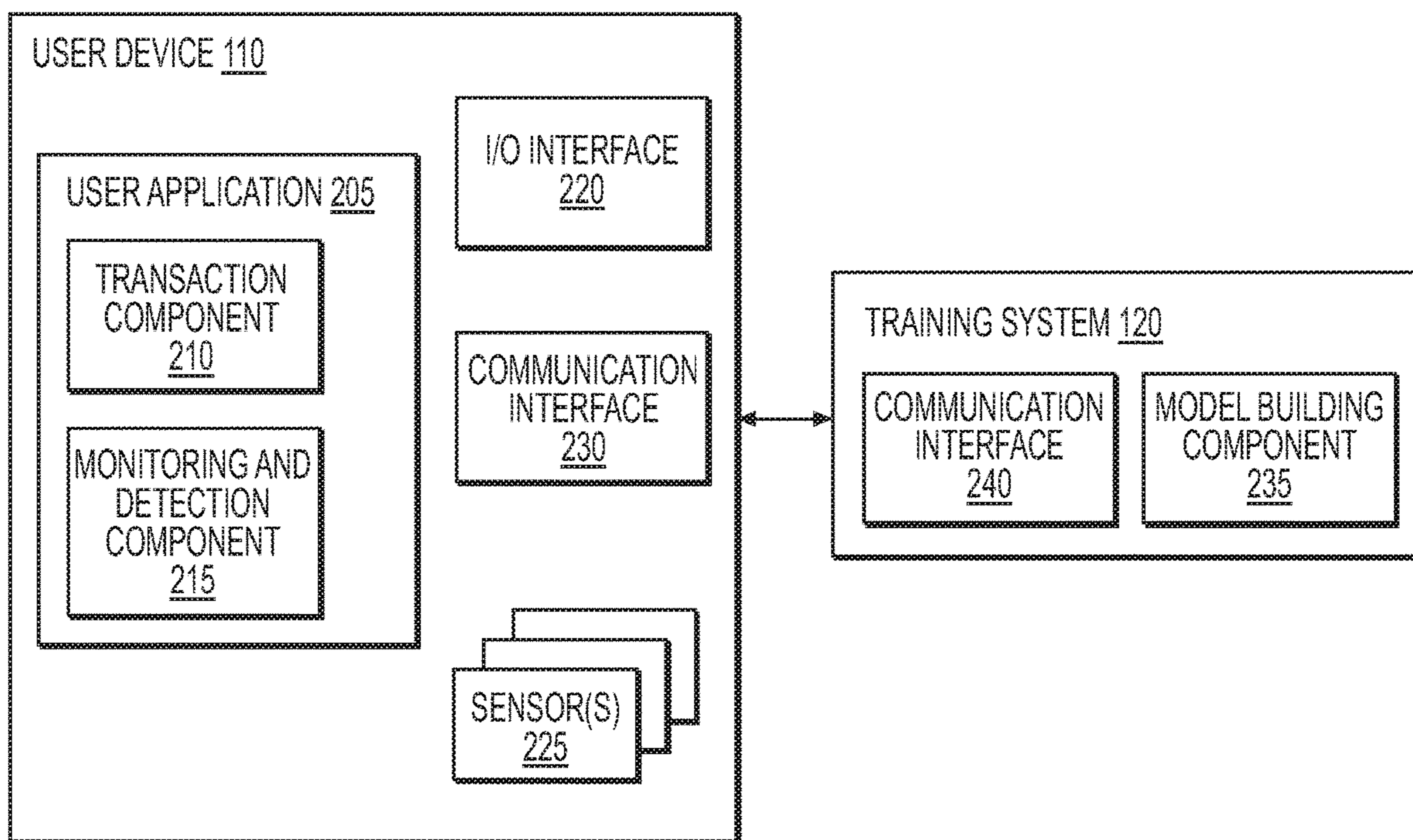


FIG. 2A

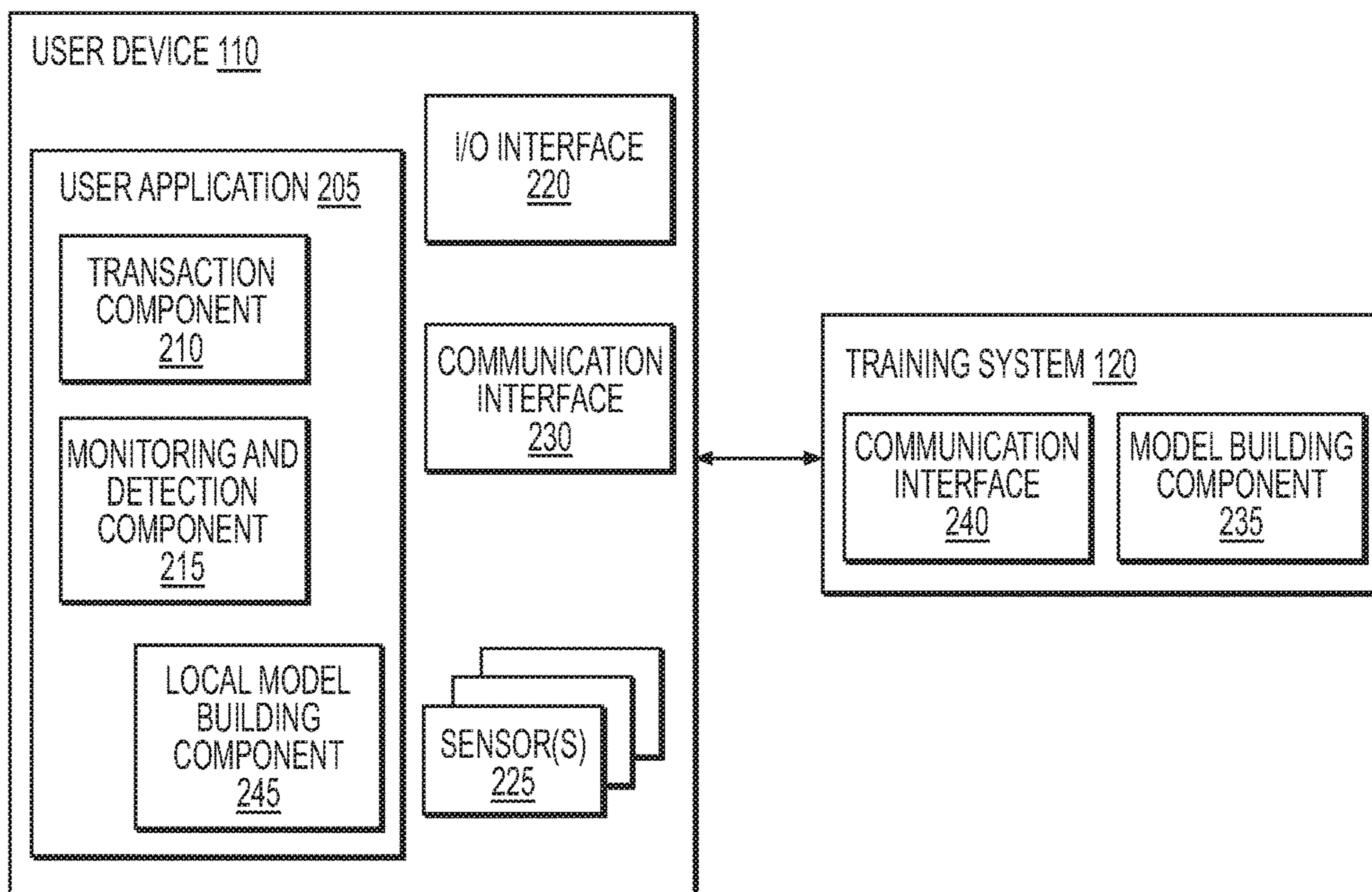


FIG. 2B

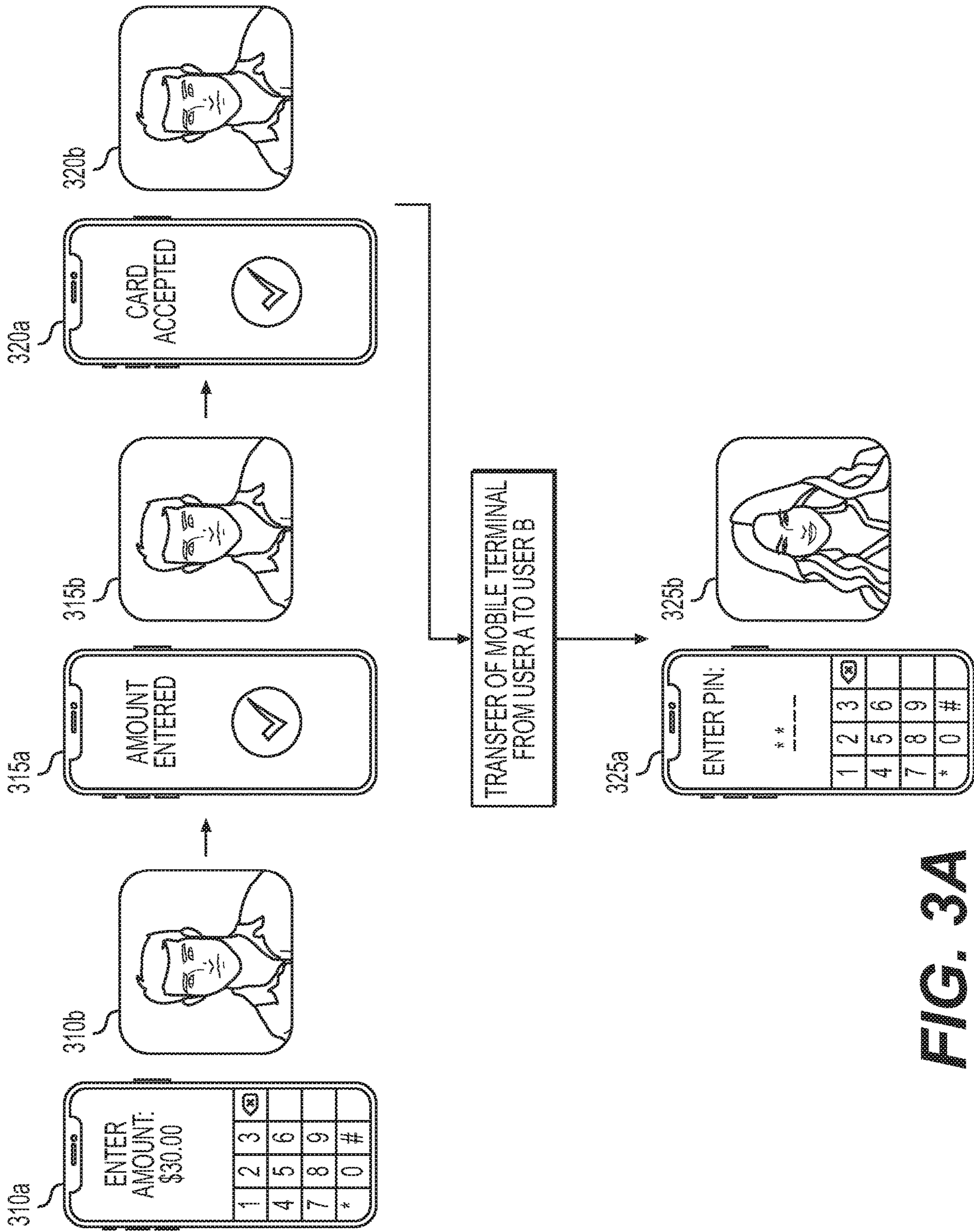


FIG. 3A

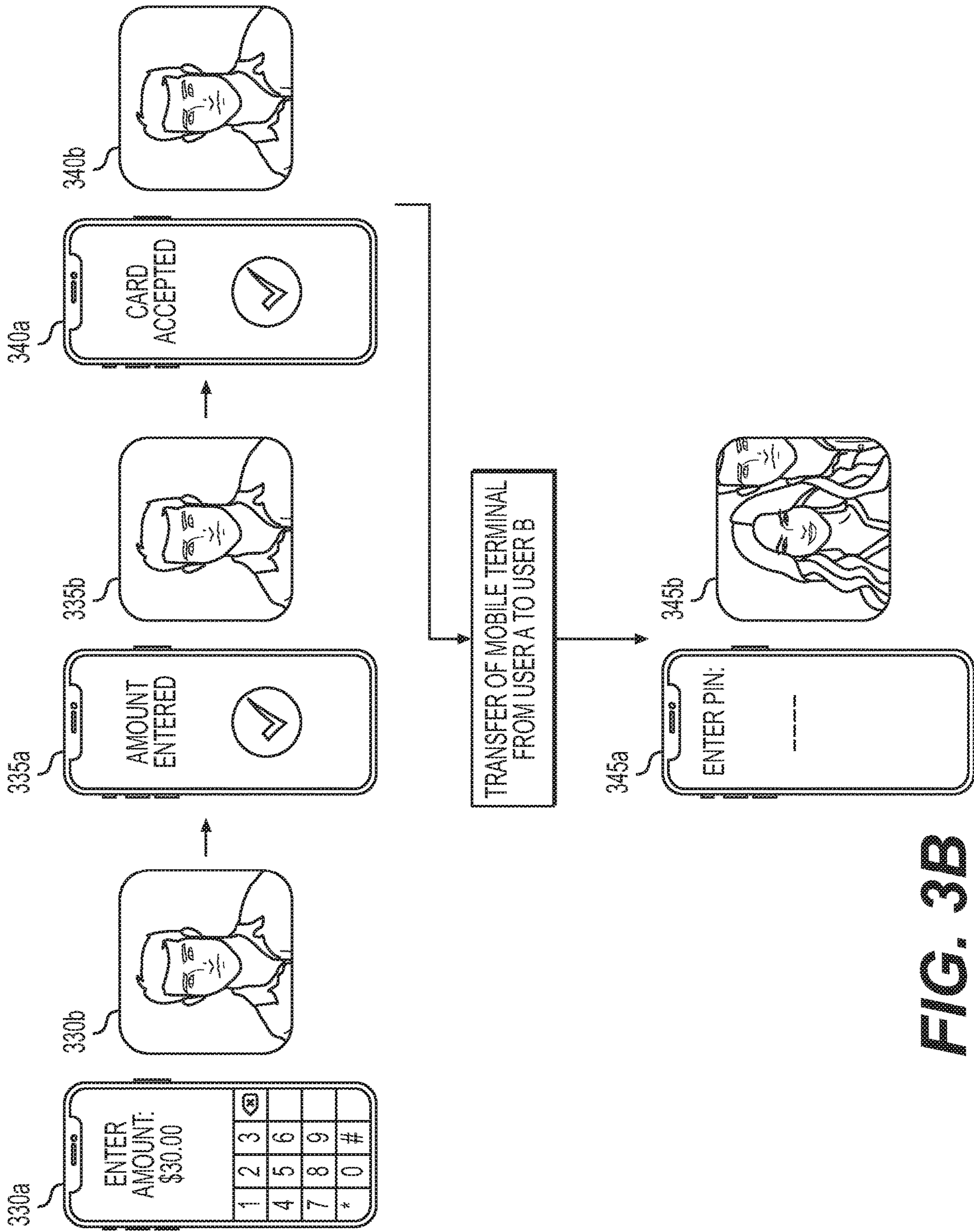


FIG. 3B

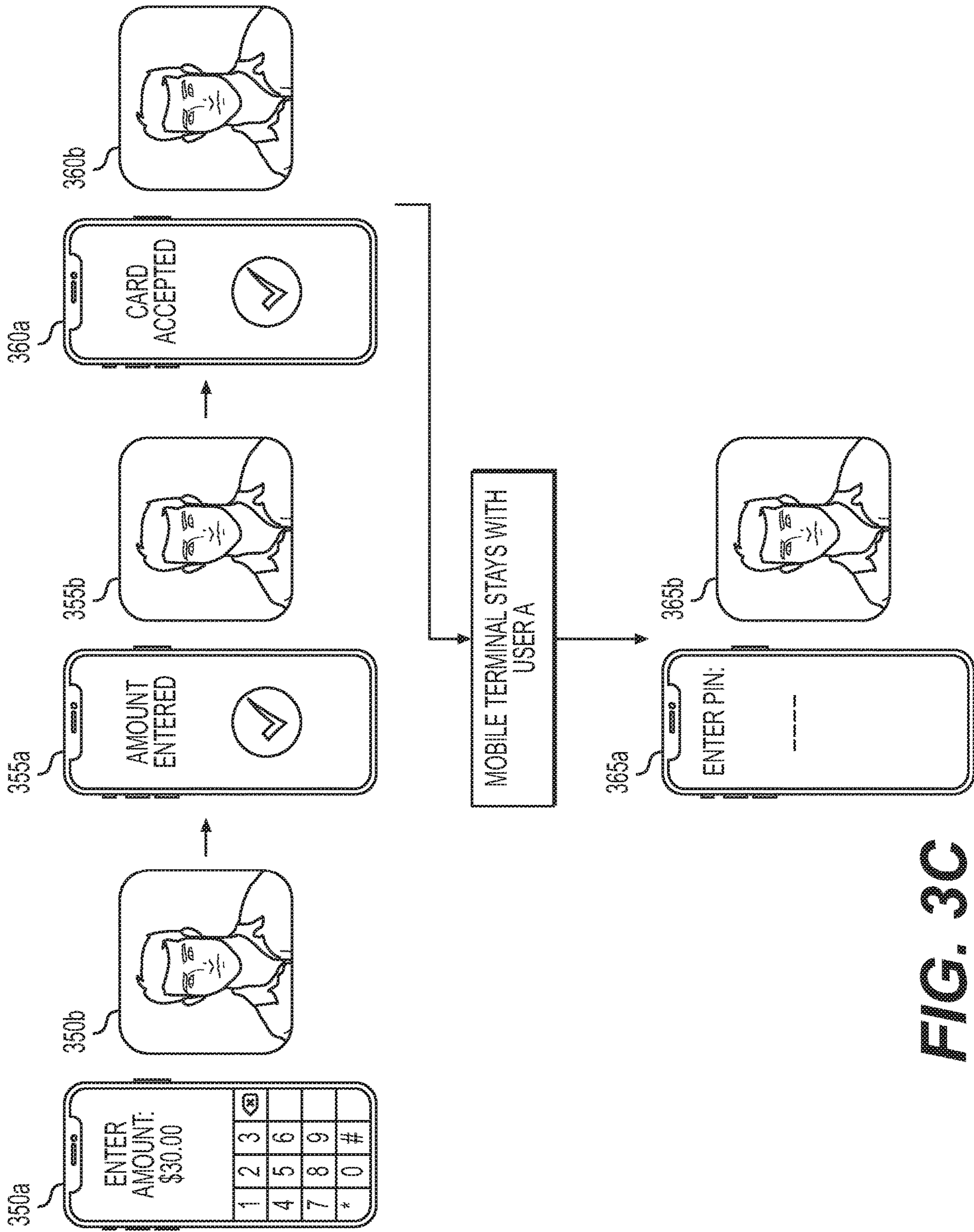


FIG. 3C

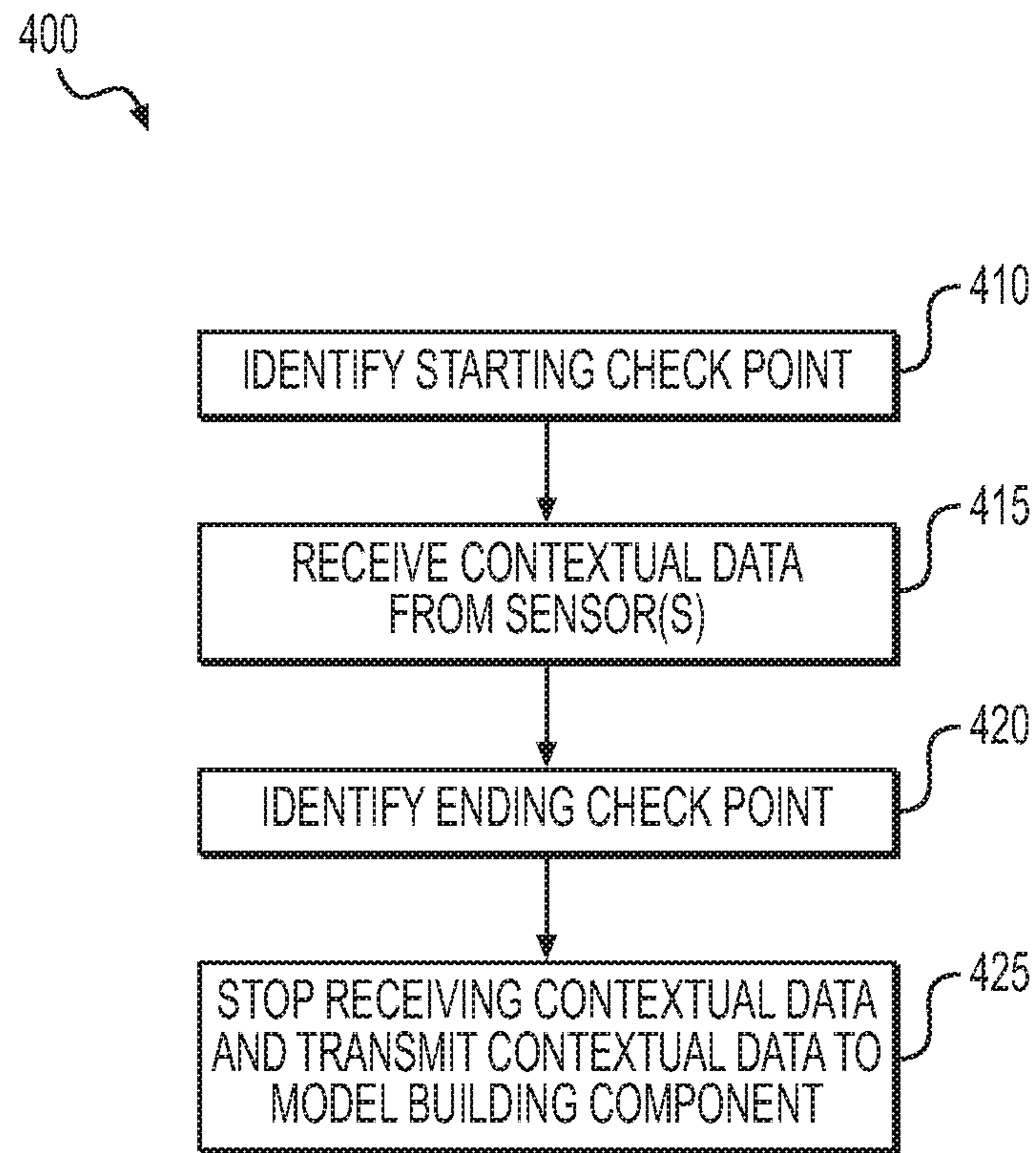


FIG. 4

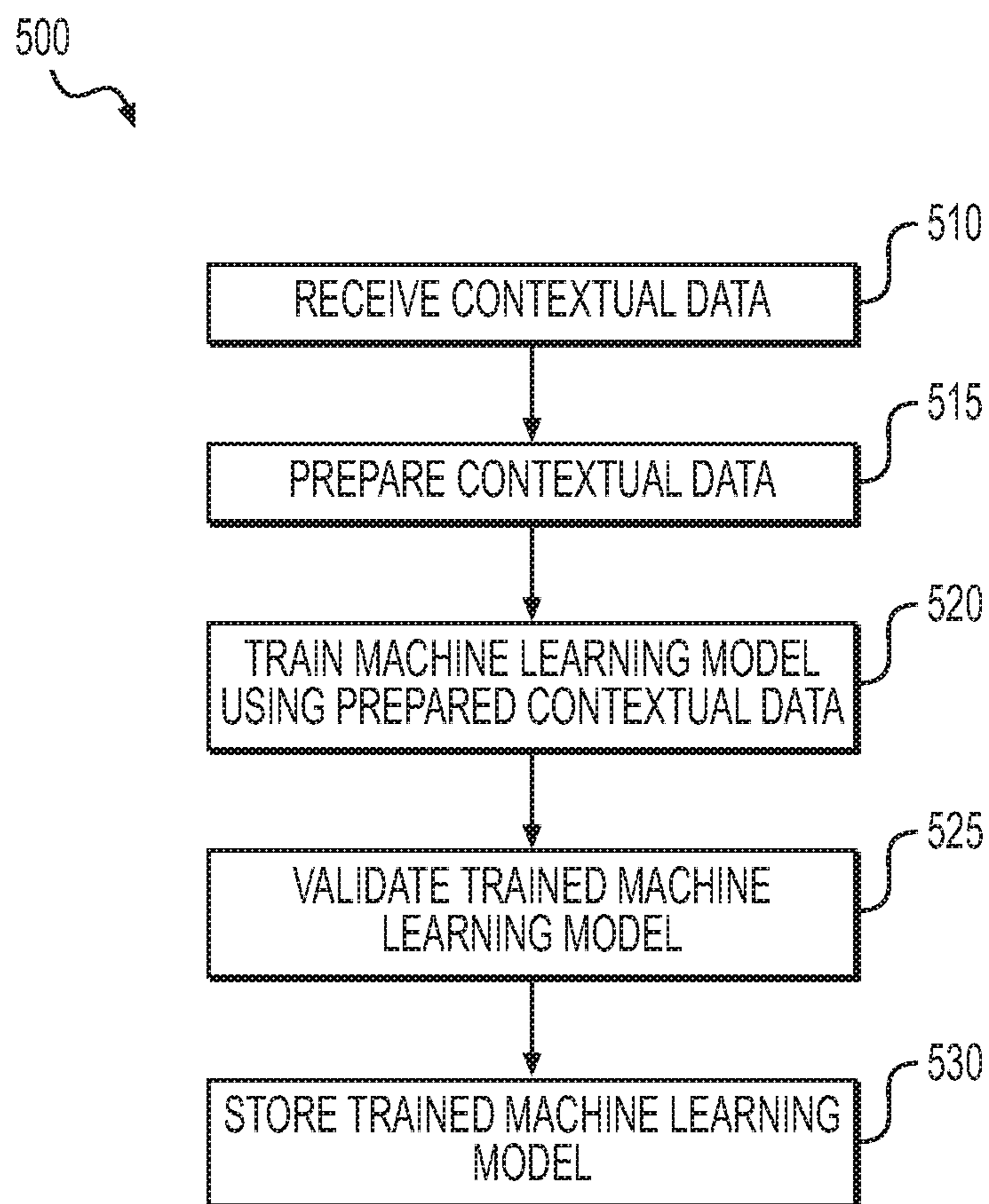


FIG. 5

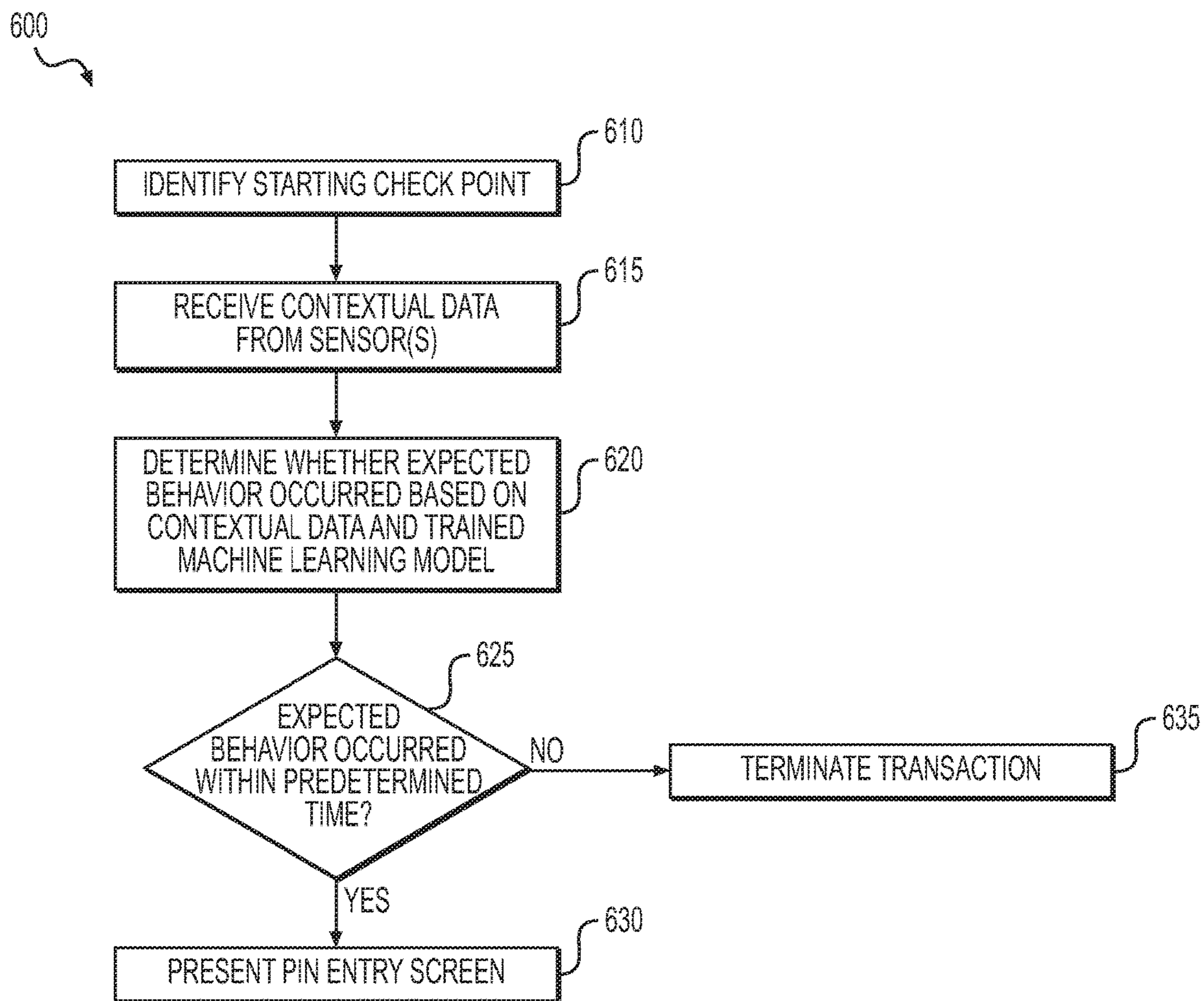


FIG. 6

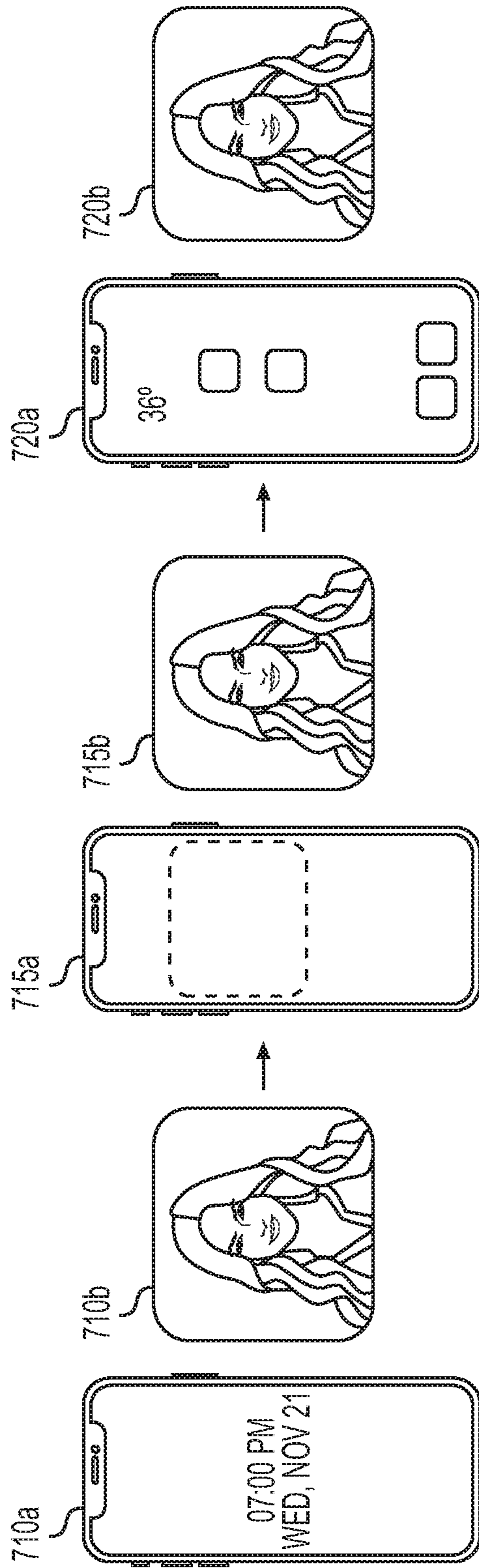


FIG. 7A

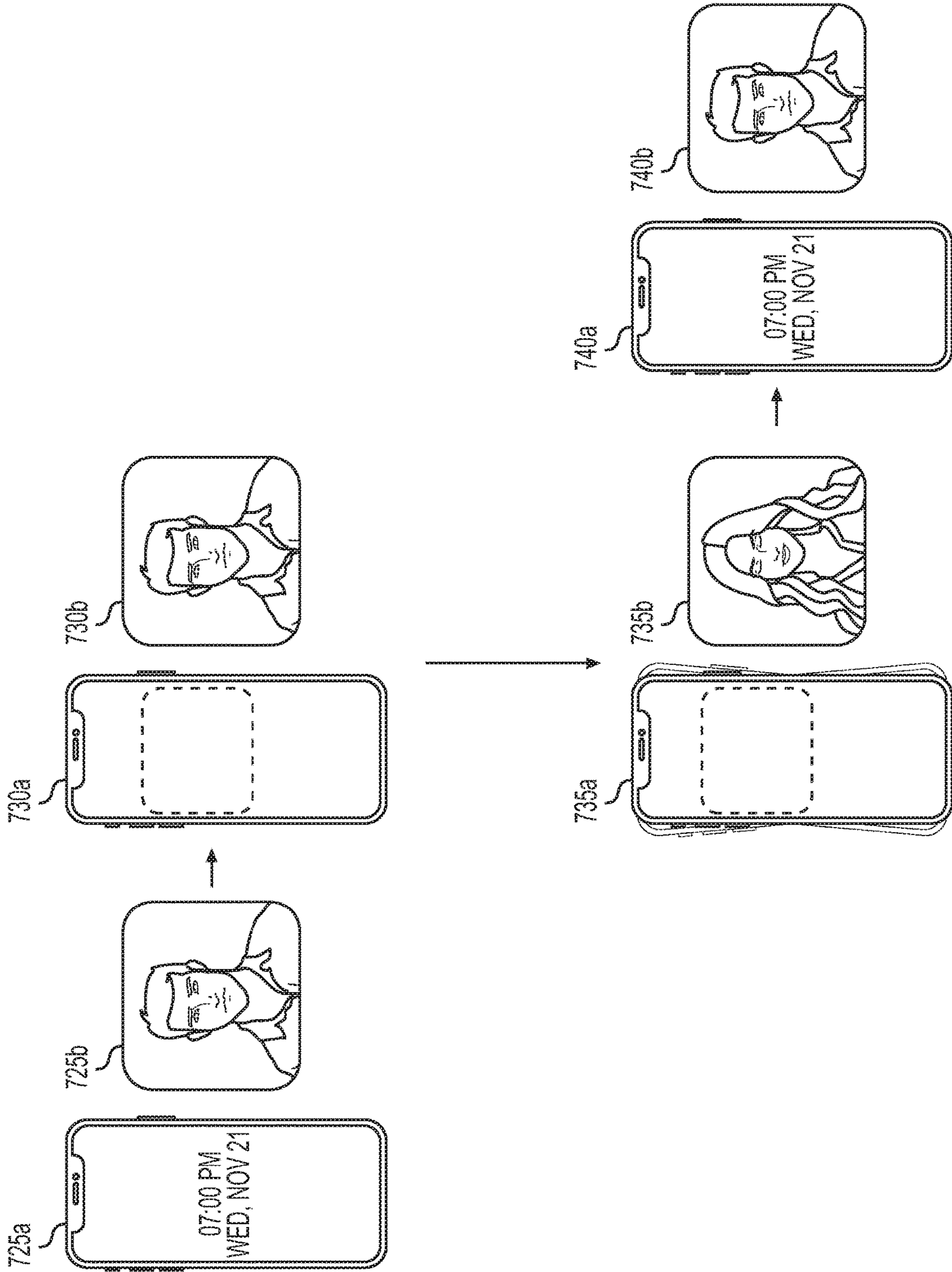


FIG. 7B

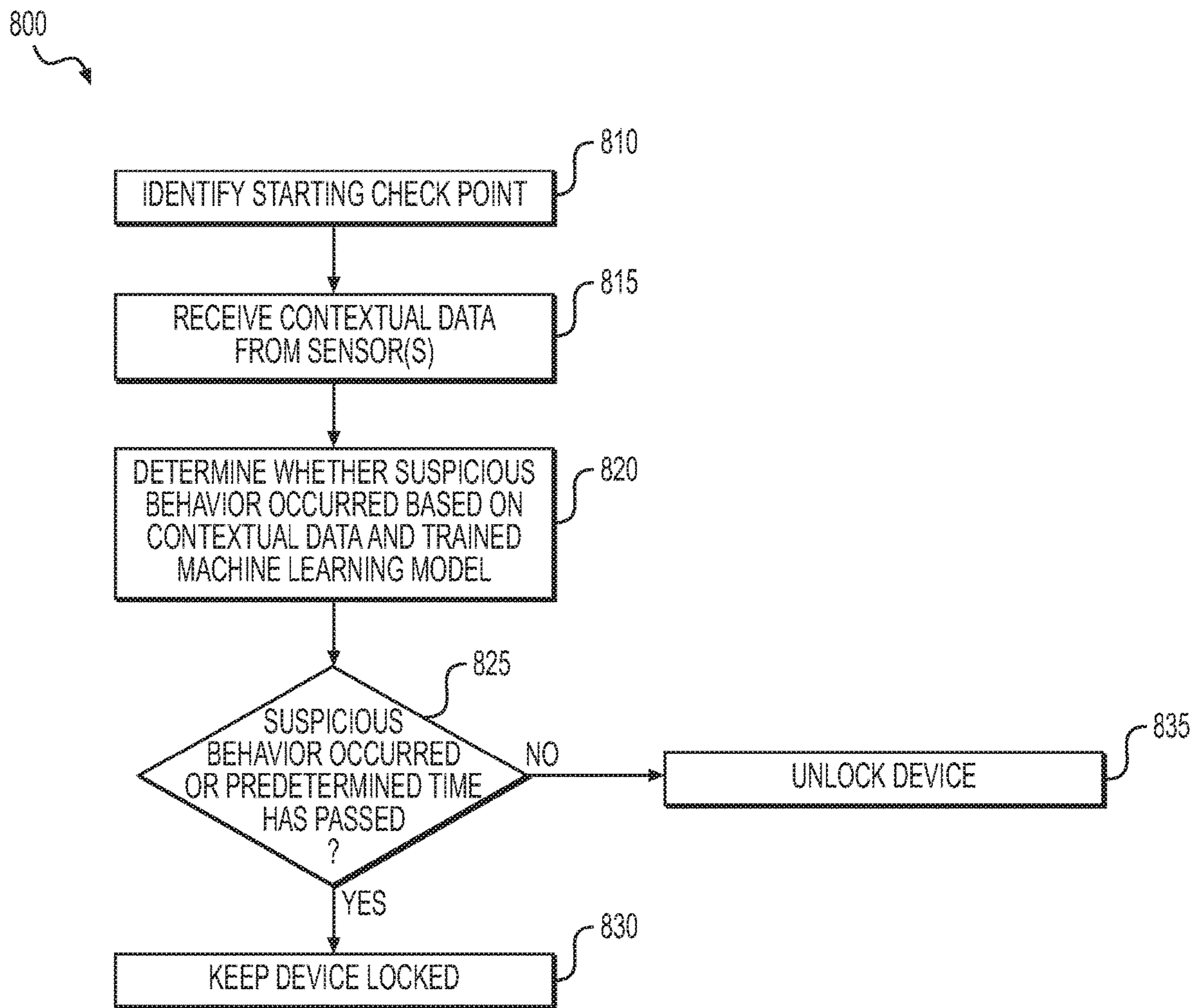


FIG. 8

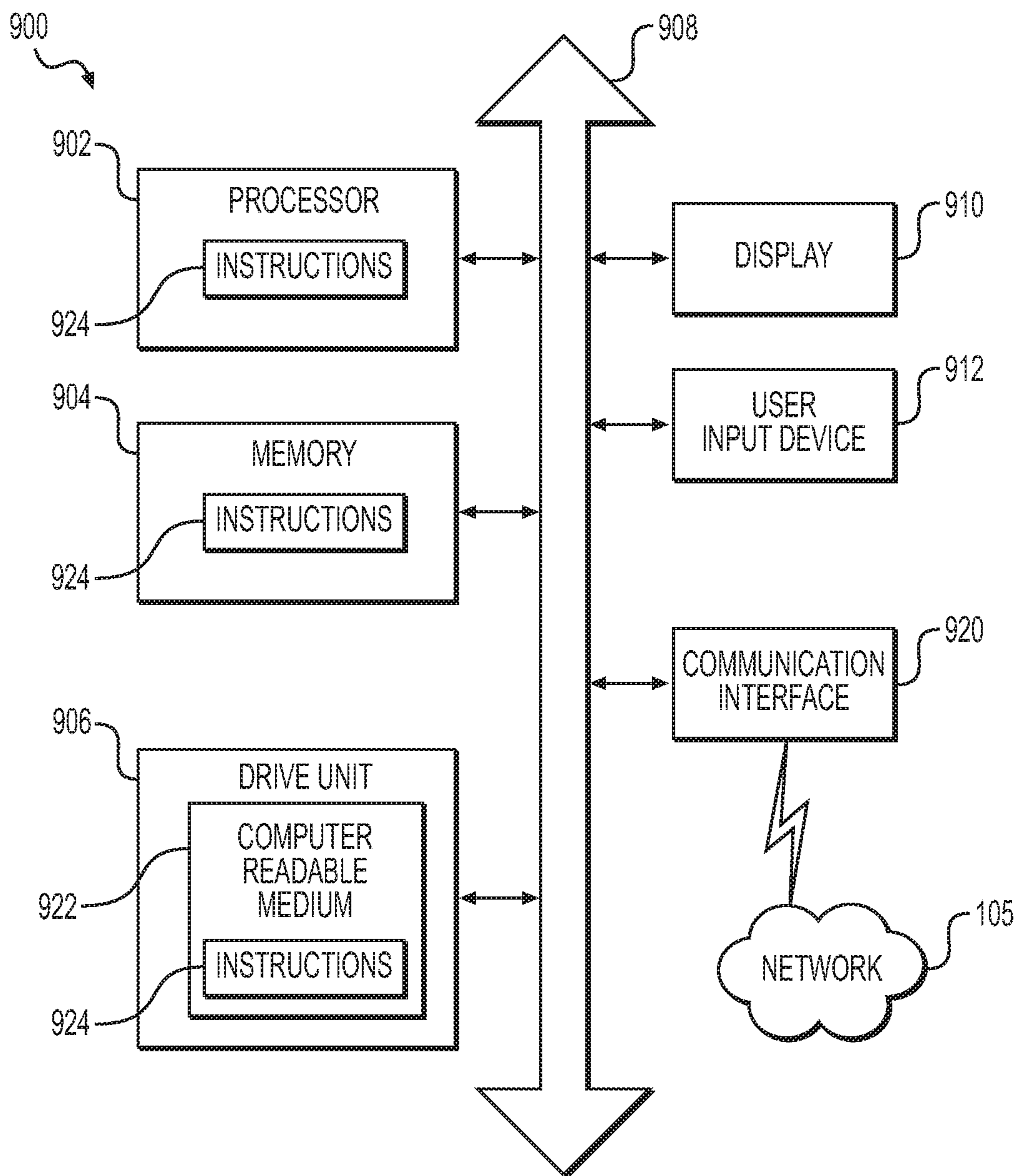


FIG. 9

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**METHODS AND SYSTEMS FOR DETECTING
SUSPICIOUS OR NON-SUSPICIOUS
ACTIVITIES INVOLVING A MOBILE
DEVICE USE**

**CROSS-REFERENCE TO RELATED
APPLICATION(S)**

This patent application is a continuation of and claims the benefit of priority to U.S. application Ser. No. 16/226,877 filed on Dec. 20, 2018, the entirety of which is incorporated herein by reference.

TECHNICAL FIELD

The present disclosure relates to methods and systems for detecting suspicious or non-suspicious activities involving a mobile device use. More particularly, the present disclosure relates to methods and systems for detecting suspicious or non-suspicious activities based on contextual data captured by sensors of a user device. The present disclosure further relates to methods and systems for analyzing contextual data to identify suspicious or non-suspicious activities using machine learning.

BACKGROUND

Mobile devices such as smartphones and tablets are becoming more capable of various functions based on the development of hardware, software, and accessories. One such capability is the processing of a transaction between a customer and a merchant using a mobile device. Typically, a merchant uses a mobile device and an accessory device to read information from a customer's account card and then process the transaction through a third party authorization entity. A downloadable application can turn an ordinary mobile device into a mobile point of sale or mobile payment acquiring terminal. While mobile terminals enable more people to conduct electronic payment transactions in a convenient and flexible manner, security concerns involving mobile terminals are rising.

Thus, a need exists for improving security of mobile device usage in various types of transactions. More particularly, there is a need for improving security of electronic payment transactions occurring through a mobile terminal.

The background description provided herein is for the purpose of generally presenting the context of the disclosure. Unless otherwise indicated herein, the materials described in this section are not prior art to the claims in this application and are not admitted to be prior art, or suggestions of the prior art, by inclusion in this section.

SUMMARY OF THE DISCLOSURE

One embodiment provides a computer-implemented method for detecting a suspicious activity and/or a non-suspicious activity during an electronic transaction performed by a user device, comprising: identifying, by a monitoring and detection component, a starting check point in the electronic transaction; receiving, by the monitoring and detection component, contextual data from one or more sensors of the user device; determining, by the monitoring and detection component, whether an expected behavior occurred based on the received contextual data and a machine learning model; in response to determining that the expected behavior occurred, enabling, by the monitoring and detection component, entry of user credentials; and in

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response to determining that the expected behavior did not occur, terminating, by the monitoring and detection component, the electronic transaction.

One embodiment provides a system for detecting a suspicious activity and/or a non-suspicious activity during an electronic transaction performed by a user device. The system may comprise one or more processors; and a non-transitory computer readable medium storing instructions which, when executed by the one or more processors, cause the one or more processors to perform a method comprising: identifying, by a monitoring and detection component, a starting check point in the electronic transaction; receiving, by the monitoring and detection component, contextual data from one or more sensors of the user device; determining, by the monitoring and detection component, whether an expected behavior occurred based on the received contextual data and a machine learning model; in response to determining that the expected behavior occurred, enabling, by the monitoring and detection component, entry of user credentials; and in response to determining that the expected behavior did not occur, terminating, by the monitoring and detection component, the electronic transaction.

One embodiment provides a non-transitory computer readable medium for detecting a suspicious activity and/or a non-suspicious activity during an electronic transaction performed by a user device. The non-transitory computer readable medium may store instructions that, when executed by one or more processors, cause the one or more processors to perform a method comprising: identifying, by a monitoring and detection component, a starting check point in the electronic transaction; receiving, by the monitoring and detection component, contextual data from one or more sensors of the user device; determining, by the monitoring and detection component, whether an expected behavior occurred based on the received contextual data and a machine learning model; in response to determining that the expected behavior occurred, enabling, by the monitoring and detection component, entry of user credentials; and in response to determining that the expected behavior did not occur, terminating, by the monitoring and detection component, the electronic transaction.

Additional objects and advantages of the disclosed embodiments will be set forth in part in the description that follows, and in part will be apparent from the description, or may be learned by practice of the disclosed embodiments. The objects and advantages of the disclosed embodiments will be realized and attained by means of the elements and combinations particularly pointed out in the appended claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the disclosed embodiments, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate various exemplary embodiments and together with the description, serve to explain the principles of the disclosed embodiments.

FIG. 1 depicts an exemplary system infrastructure of communicatively coupled user device(s), a host system, and a training system, according to one aspect of the present disclosure.

FIG. 2A depicts an exemplary embodiment of a user device and a training system, according to one aspect of the present disclosure.

FIG. 2B depicts another exemplary embodiment of a user device and a training system, according to one aspect of the present disclosure.

FIG. 3A is an exemplary use case diagram illustrating interactions between users and a user device during an electronic payment transaction.

FIG. 3B is another exemplary use case diagram illustrating interactions between users and a user device during an electronic payment transaction.

FIG. 3C is another exemplary use case diagram illustrating interactions between a user and a user device during an electronic payment transaction.

FIG. 4 is a flowchart illustrating an exemplary method of aggregating contextual data for model building, according to one aspect of the present disclosure.

FIG. 5 is a flowchart illustrating an exemplary method of training a machine learning model, according to one aspect of the present disclosure.

FIG. 6 is a flowchart illustrating an exemplary method of analyzing contextual data to determine an occurrence of an expected activity, according to one aspect of the present disclosure.

FIG. 7A is an exemplary use case diagram illustrating interactions between a user and a user device during unlocking of the user device.

FIG. 7B is an exemplary use case diagram illustrating interactions between users and a user device during unlocking of the user device.

FIG. 8 is a flowchart illustrating an exemplary method of analyzing contextual data to determine an occurrence of a suspicious activity, according to one aspect of the present disclosure.

FIG. 9 illustrates an implementation of a general computer system that may execute techniques presented herein.

DETAILED DESCRIPTION OF EMBODIMENTS

The following embodiments describe methods and systems for detecting suspicious or non-suspicious activities based on contextual data captured by sensors of a user device and, more particularly, for analyzing contextual data to identify suspicious or non-suspicious activities using machine learning.

With the wide spread use of mobile devices, many applications have been developed to enable mobile devices to perform various functions and transactions. For example, a downloadable software application can turn an ordinary mobile device into a mobile point of sale or mobile payment acquiring terminal (collectively, a “mobile terminal”). Using the mobile terminal, an electronic payment transaction can be initiated by a seller who may take a payment electronically from a buyer. For certain transactions, an entry of user credentials (via a security challenge) may be required upon a buyer “swiping” or “tapping” a payment vehicle at the mobile terminal. If such a transaction is initiated at a seller’s mobile terminal, the security challenge may be presented on the seller’s mobile device. Thus, the seller may be required to present or transfer the device to the buyer who may enter his/her user credentials. For example, the buyer may be requested to enter a personal identification number (PIN) associated with the payment vehicle.

To make this process more secure, the disclosed embodiment is directed to detecting suspicious or non-suspicious activities during an electronic transaction performed at a

user device. In one embodiment, the methods and systems of the present disclosure may enable determination of whether a user device has been passed from one user to another (i.e., from a seller to a buyer) for an entry of user credentials. The determination may be based on contextual data collected from various sensors implemented in the user device. Based on the result of the determination, the entry of the user credentials may be enabled or disabled. The methods and systems of the present disclosure may be applicable to a variety of contexts, and may not be limited to the use case scenarios specifically discussed herein.

The subject matter of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings, which form a part hereof, and which show, by way of illustration, specific exemplary embodiments. An embodiment or implementation described herein as “exemplary” is not to be construed as preferred or advantageous, for example, over other embodiments or implementations; rather, it is intended to reflect or indicate that the embodiment(s) is/are “example” embodiment(s). Subject matter may be embodied in a variety of different forms and, therefore, covered or claimed subject matter is intended to be construed as not being limited to any exemplary embodiments set forth herein; exemplary embodiments are provided merely to be illustrative. Likewise, a reasonably broad scope for claimed or covered subject matter is intended. Among other things, for example, subject matter may be embodied as methods, devices, components, or systems. Accordingly, embodiments may, for example, take the form of hardware, software, firmware or any combination thereof (other than software per se). The following detailed description is, therefore, not intended to be taken in a limiting sense.

Throughout the specification and claims, terms may have nuanced meanings suggested or implied in context beyond an explicitly stated meaning. Likewise, the phrase “in one embodiment” as used herein does not necessarily refer to the same embodiment and the phrase “in another embodiment” as used herein does not necessarily refer to a different embodiment. It is intended, for example, that claimed subject matter include combinations of exemplary embodiments in whole or in part.

The terminology used below may be interpreted in its broadest reasonable manner, even though it is being used in conjunction with a detailed description of certain specific examples of the present disclosure. Indeed, certain terms may even be emphasized below; however, any terminology intended to be interpreted in any restricted manner will be overtly and specifically defined as such in this Detailed Description section.

Referring now to the appended drawings, FIG. 1 shows an exemplary system infrastructure of communicatively coupled user device(s), a training system, and a host system. In general, FIG. 1 depicts user device(s) **110**, training system **120**, and host system **115**, all connected via network **105**. Network **105** may include the Internet, but may also include other networks such as a corporate WAN, cellular network, satellite network, or combination thereof, for example. The network **105** may be employed to enable data communications between the various entities illustrated in FIG. 1 (i.e., user device(s) **110**, training system **120**, and host system **115**).

User device **110** may comprise a computing system consistent with or similar to that depicted in FIG. 9. In one embodiment, user device **110** may be a mobile device comprising a computing system consistent with or similar to that depicted in FIG. 9. The term “mobile device” used

herein may refer to a smart phone, a table, a laptop, a smart watch, a wearable device, a gaming device, a handheld computer, a portable media player, or any other mobile or portable computing device. User device **110** may be equipped with various sensors such as, for example, global positioning system (GPS) sensors, vision sensors (i.e., cameras), audio sensors (i.e., microphones), light sensors, temperature sensors, radio frequency sensors, direction sensors (i.e., magnetic compasses, magnetometers, gyroscopes), and acceleration sensors (i.e., accelerometers). User device **110** may use these sensors to capture contextual data. The contextual data may be used to train a machine learning model and to detect suspicious and/or non-suspicious activities involving device usage. In some embodiments, user device **110** may be configured to leverage an external card reader peripheral device to become an ad hoc Point of Sale (POS) platform.

Training system **120** may comprise one or more computer servers consistent with or similar to that depicted in FIG. 9. Training system **120** may comprise a single server, or a plurality of servers distributed across the network **105**. Notably, training system **120** may receive contextual data from user device(s) **110** and may train a machine learning model using the collected contextual data. Training system **120** may receive contextual data from one or more user devices **110** in order to analyze use patterns across an entire or a portion of a user base. Training system **120** may provide the trained machine learning model to user device(s) **110**, in order for the user device(s) **110** to detect suspicious and/or non-suspicious activities based on contextual data captured in real-time.

Host system **115** may comprise one or more computer servers consistent with or similar to that depicted in FIG. 9. Host system **115** may comprise a single server, or a plurality of servers distributed across the network **105**. Notably, host system **115** may store software applications which may be requested and downloaded by the user device(s) **110**. As will be described in greater detail below, user device(s) **110** may include a user application **205** installed thereon, to perform electronic transactions, monitor device usage, and detect suspicious and/or non-suspicious activities. Such an application may be provided from the host system **115** for download. For example, host system **115** may be a server hosted by a banking institution, and the software application available for download at the host system **115** may be an electronic payment transaction application. As another example, host system **115** may be a server hosted by an application developer, and may have a variety of software applications available for download. As another example, host system **115** may be implemented as part of a payment network comprising, for example, an issuer computing system, an acquirer computing system, and a POS system. For instance, host system **115** may be implemented as part of the issuer computing system or the acquirer computing system, and may store and provide electronic transaction-related software applications to the user device(s) **110**. Notwithstanding the specific examples discussed above, in general, host system **115** may be any server suitable for storing and providing a software application to the user device(s) **110**.

FIG. 2A depicts an exemplary embodiment of a user device **110** and a training system **120**, according to one aspect of the present disclosure. User device **110** may comprise a user application **205**, an input/output (I/O) interface **220**, sensor(s) **225**, and a communication interface **230**. User application **205** may be a software application downloaded from a host system **115** and installed on the user device **110**. In one embodiment, user application **205** may

comprise a transaction component **210** and a monitoring and detection component **215**. Transaction component **210** may be configured to carry out an electronic transaction for which the user application **205** is designed. For example, if the user application **205** is an electronic payment transaction application, transaction component **210** may configure the user device **110** as an ad hoc POS platform, and may enable the user device **110** to present graphical user interface elements to walk a user through a number of steps in an electronic payment transaction. As another example, the user application **205** may be a device security application, and the transaction component **210** may enable a user to unlock the user device **110** upon receiving certain contextual data such as, for example, user biometrics (which may also involve presenting graphical user interface elements to walk a user through one or more biometrics collection steps).

Monitoring and detection component **215** may be configured to collect contextual data using one or more sensors **225** of the user device **110**, in order to detect suspicious and/or non-suspicious activities involving device usage. As alluded to above, the sensor(s) **225** may include global positioning system (GPS) sensors, vision sensors (i.e., cameras), audio sensors (i.e., microphones), light sensors, temperature sensors, radio frequency sensors, direction sensors (i.e., magnetic compasses, magnetometers, gyroscopes), and acceleration sensors (i.e., accelerometers). Monitoring and detection component **215** may identify a check point (i.e., a starting check point) at which to begin capturing contextual data using the sensor(s) **225**, and may also identify another check point (i.e., an ending check point) at which to halt capturing contextual data using the sensor(s) **225**, based on data provided by the transaction component **210**. Monitoring and detection component **215** may transmit the contextual data to training system **120** for further processing/analysis, using communication interface **230**. I/O interface **220** may provide an interface to connect with peripheral devices such as, for example, display devices, integrated input mechanisms (e.g., keyboards, touch screens, mice, etc.), printers, storage devices, payment input mechanisms (e.g., magnetic card reader devices, smart card readers, optical readers, etc.), speakers and headphones, etc.

Training system **120** may comprise a model building component **235** and a communication interface **240**. Model building component **235** may receive contextual data from the user device **110**, and may train a machine learning model using the contextual data. In one embodiment, model building component **235** may receive contextual data from a plurality of user devices **110**, train a machine learning model to be representative of behaviors across an entire or a portion of a user base, and provide the trained machine learning model to the plurality of user devices **110** (i.e. to the monitoring and detection components **215** of the user device(s) **110**). In another embodiment, model building component **235** may receive contextual data from a single user device **110**, train a machine learning model to be representative of behaviors localized to that user device **110**, and provide the trained machine learning model to that user device **110** (i.e., to the monitoring and detection component **215** of that user device **110**).

In yet another embodiment, as shown in FIG. 2B, user device **110** may comprise a user application **205** including a local model building component **245**, which may receive contextual data of the user device **110**, train a machine learning model to be representative of behaviors specific to the user device **110**, and provide the trained machine learning model to the monitoring and detection component **215** of the user device **110**. Meanwhile, the model building com-

ponent **235** of the training system **120** may receive contextual data from a plurality of user devices **110**, train a machine learning model to be representative of behaviors across an entire or a portion of a user base, and may provide the trained machine learning model to the plurality of user devices **110**. The machine learning model may be continuously or periodically updated as more contextual data become available at the user devices **110**, and the updated machine learning model may be periodically provided to the user devices **110**.

It should be noted that, although user device **110** and training system **120** are shown as separate entities remote from each other in FIGS. 2A-2B, the training system **120** may be implemented in the user device **110** and the processes performed by the user application **205** (e.g., transaction component **210** and monitoring and detection component **215**) and the model building component **235** may all be performed within the user device **110**. Furthermore, although transaction component **210**, monitoring and detection component **215**, and local model building component **245** are shown as separate components (i.e., application logics) within the user application **205**, these components may actually be a single component (i.e., an application logic) performing all of the functions described below with respect to the transaction component **210**, monitoring and detection component **215**, and local model building component **245**, and such a single component may be referred to as the transaction component **210** or the monitoring and detection component **215**. As such, it should be appreciated that the configurations specifically discussed herein regarding the arrangement and/or the division of the components depicted in FIGS. 2A-2B are merely exemplary, and different combinations of components may be implemented on a single device (e.g., user device **110**) or multiple computing devices (e.g., user device **110** and training system **120**) to perform the steps described in the present disclosure.

As alluded to above, user device **110** may include a user application **205** configured to perform an electronic payment transaction (i.e., an electronic payment transaction application). An electronic payment transaction application may enable a seller of goods/services to use the user device **110** as POS terminal. A user device **110** being used as a POS terminal may be referred to as a “mobile terminal” throughout the present disclosure. For example, as shown in FIG. 3A (steps **310a**, **315a**, **320a**, and **325a**), users of the user device **110**, such as a seller (i.e., user A) and/or a buyer (i.e., user B), may be presented with a series of graphical user interface screens to complete an electronic payment transaction. As alluded to above in reference to FIGS. 2A-2B, transaction component **210** of the user application **205** may enable the user device **110** to present the graphical user interface screens, and may also enable transmission of electronic payment transaction-related data to other entities in the payment network (e.g., an acquirer computing system, an issuer computing system, etc.) for payment authorization. Further, during the electronic payment transaction, monitoring and detection component **215** may direct one or more sensors of the user device **110** to capture contextual data. For example, as shown in FIG. 3A (images **310b**, **315b**, **320b**, and **325b**), an image sensor (i.e., a camera) may capture facial images of one or more users of the user device **110** during the electronic payment transaction, and may analyze the captured facial images (e.g., face recognition, comparison of the recognized faces, etc.) to detect a suspicious and/or non-suspicious activity.

Now with reference to FIG. 3A, more detailed description of the graphical user interface screens of the user application

205 (i.e., electronic payment transaction application) and the contextual data captured at different stages of the electronic payment transaction will be provided. Notably, FIG. 3A illustrates a context in which the embodiments contemplated by the present disclosure may be applied. At step **310a**, transaction component **210** of the user application **205** may present a screen where a seller may enter a transaction amount for a sale of goods/services. At step **315a**, in response to the seller entering the transaction amount, transaction component **210** may confirm that the transaction amount has been successfully entered by displaying “Amount Entered” with a check mark. Although not shown in FIG. 3A, in addition to confirming the successful entry of the transaction amount, transaction component **210** may also display instructions for a buyer to provide a payment vehicle. A payment vehicle may be embodied as a physical payment card (e.g., a traditional payment card such as a credit card, a debit card, a pre-paid card, a single-use card, etc.) or a virtual payment card (e.g., a digital wallet, etc.). The user application **205** may be configured to process both types of payment vehicle using a built-in or peripheral device such as, for example, a magnetic card reader, a contactless reader, a contactless near field communication (NFC) reader, etc. At step **320a**, in response to receiving the payment vehicle, transaction component **210** may confirm that the payment vehicle has been successfully “swiped” or “tapped” at the mobile terminal.

While the transaction component **210** may perform tasks directly related to processing/completing the electronic payment transaction, monitoring and detection component **215** may collect contextual data using sensors of the user device **110**, to identify suspicious and/or non-suspicious activities that might be associated with the electronic payment transaction. In one embodiment, monitoring and detection component **215** may direct an image sensor of the user device **110** (i.e., camera) to capture a facial image of the person using the device. This way, monitoring and detection component **215** may be able to capture the facial image of the person who is using or facing the device screen when the transaction amount is entered (i.e., facial image **310b**), when the successful entry of the transaction amount is confirmed (i.e., facial image **315b**), and/or when the successful provision of the payment vehicle is confirmed (i.e., facial image **320b**). In the case of the scenario depicted in FIG. 3A, the facial images **310b**, **315b**, **320b** captured at the electronic payment transaction stages **310a**, **315a**, **320a** are of a seller (i.e., user A). The facial images captured during the electronic payment transaction may be stored locally and/or remotely for further analysis.

With continuing reference to FIG. 3A, once the payment vehicle is accepted by the mobile terminal (step **320a**), at step **325a**, transaction component **210** may present a screen where the owner of the payment vehicle (i.e., the buyer) may enter the user credentials associated with the payment vehicle. The user credentials may include, but may not be limited to, a personal identification number (PIN), a passcode, a birthday, an address, a postal/zip code, an answer to a security question, a social security number, etc. In FIG. 3A, a PIN entry screen is shown as an example. Notably, transaction component **210** may present the PIN entry screen only if the monitoring and detection component **215** determines that the person attempting to enter the PIN is different from the seller, whose facial images were captured at the earlier steps (i.e., **310a**, **315a**, and/or **320a**) and stored. Alternatively, transaction component **210** may present the PIN entry screen subsequent to the successful provision of the payment vehicle, but may disable input of numerical

digits (e.g., by hiding the numeric keypad) until the monitoring and detection component **215** determines that the person attempting to enter the PIN is different from the seller. Therefore, monitoring and detection component **215** may be configured to identify that the seller (or the person
5 who set up and/or initiated the electronic payment transaction) has actually presented or transferred the user device **110** to a buyer to answer a security challenge (i.e., provide user credentials) for payment vehicle authentication, and ensure that it is not the seller who is attempting to provide the answer.

In one embodiment, after the payment vehicle is accepted by the mobile terminal at step **320a**, monitoring and detection component **215** may direct the image sensor of the user device **110** to capture one or more facial images of the person facing the device screen. If the face recognized from the captured one or more facial images (e.g., via face recognition technology) is different from the seller's face recognized from the facial images **310b**, **315b**, **320b**, the monitoring and detection component **215** may direct the transaction component **210** to present the PIN entry screen.

In FIG. **3A**, the face recognized from the facial image **325b** captured subsequent to the acceptance of the payment vehicle is different from the face recognized from any of the facial images **310a**, **315a**, **320b**. Accordingly, the PIN entry option is displayed as shown in step **325a**. In another embodiment, after the payment vehicle is accepted by the mobile terminal at step **320a**, transaction component **210** may present the PIN entry option with the numeric keypad disabled or hidden. Concurrently, monitoring and detection component **215** may direct the image sensor of the user device **110** to capture one or more facial images of the person facing the device screen, and if the face recognized from the captured one or more facial images are different from that of the facial images **310b**, **315b**, **320b**, may direct the transaction component **210** to enable or reveal the numeric keypad for PIN entry.

As will be described in greater detail in the following sections, contextual data used to detect suspicious (e.g., non-transfer of the phone, multiple faces recognized from an image captured at the PIN entry stage, etc.) and/or non-suspicious activities (e.g., transfer of the phone, a single face recognized from an image captured at the PIN entry stage, etc.) may not only include data captured by image sensors of the user device **110**, but may also include data captured by other sensors of the device **110**. In some cases, using various types of contextual data may provide more reliable and accurate detection results compared to using one type of contextual data. Therefore, it should be appreciated that, while the description pertaining to FIG. **3A** above and FIGS. **3B-3C** below may specifically discuss the use of an image sensor, other types of data may also be captured by other sensors to improve accuracy and reliability of the detection results.

FIG. **3B** is another exemplary use case diagram illustrating graphical user interface screens of the user application **205** (i.e., electronic payment transaction application) and the contextual data captured at different stages of the electronic payment transaction. FIG. **3B** also illustrates a context in which the embodiments contemplated by the present disclosure may be applied.

At step **330a**, transaction component **210** of the user application **205** may present a screen where a seller may enter a transaction amount for a sale of goods/services. At step **335a**, in response to the seller entering the transaction amount, transaction component **210** may confirm that the transaction amount has been successfully entered by dis-

playing "Amount Entered" with a check mark. In addition to confirming the successful entry of the transaction amount, transaction component **210** may also display instructions for a buyer to provide a payment vehicle. At step **340a**, in response to receiving the payment vehicle, transaction component **210** may confirm that the payment vehicle has been successfully "swiped" or "tapped" at the mobile terminal.

As discussed above in reference to FIG. **3A**, to identify suspicious and/or non-suspicious activities that might be associated with the electronic payment transaction, monitoring and detection component **215** may direct an image sensor of the user device **110** to capture the facial image of the person who is using or facing the device screen when the transaction amount is entered (facial image **330b**), when the successful entry of the transaction amount is confirmed (facial image **335b**), and/or when the successful provision of the payment vehicle is confirmed (facial image **340b**). In the case of the scenario depicted in FIG. **3B**, the facial images **330b**, **335b**, **340b** captured at the electronic payment transaction stages **330a**, **335a**, **340a** are of a seller (i.e., user A).

Once the payment vehicle is accepted by the mobile terminal (step **340a**), at step **345a**, transaction component **210** may present a screen where a buyer may enter a PIN for authentication. Notably, transaction component **210** may enable the PIN entry (e.g., by displaying a numeric keypad) only if the monitoring and detection component **215** determines that the person attempting to enter the PIN is different from the seller. More particularly, transaction component **210** may enable the PIN entry only if the facial image captured at the PIN entry stage is of a single person that is different from the seller, which may indicate that the device **110** has been transferred from the seller, and that there is only one person viewing/entering the PIN. For example, in FIG. **3B**, the image **345b** captured at step **345a** include two faces—of a buyer and a second person. Although the face of the buyer may suggest that the user device **110** has been transferred to the buyer, the face of the second person may further suggest that a person other than the buyer may be watching the PIN entry. Accordingly, the PIN entry may remain disabled until the second person moves out of the shot.

FIG. **3C** is another exemplary use case diagram illustrating graphical user interface screens of the user application **205** (i.e., electronic payment transaction application) and the contextual data captured at different stages of the electronic payment transaction. FIG. **3C** also illustrates a context in which the embodiments contemplated by the present disclosure may be applied.

At step **350a**, transaction component **210** of the user application **205** may present a screen where a seller may enter a transaction amount for a sale of goods/services. At step **355a**, in response to the seller entering the transaction amount, transaction component **210** may confirm that the transaction amount has been successfully entered by displaying "Amount Entered" with a check mark. In addition to confirming the successful entry of the transaction amount, transaction component **210** may also display instructions to provide a payment vehicle. At step **360a**, in response to receiving the payment vehicle, transaction component **210** may confirm that the payment vehicle has been successfully "swiped" or "tapped" at the mobile terminal.

As discussed above in reference to FIG. **3A**, to identify suspicious and/or non-suspicious activities that might be associated with the electronic payment transaction, monitoring and detection component **215** may direct an image sensor of the user device **110** to capture the facial image of the person who is using or facing the device screen when the

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transaction amount is entered (facial image **350b**), when the successful entry of the transaction amount is confirmed (facial image **355b**), and/or when the successful provision of the payment vehicle is confirmed (facial image **360b**). In the case of the scenario depicted in FIG. 3C, the facial images **350b**, **355b**, **360b** captured at the electronic payment transaction stages **350a**, **355a**, **360a** are of a seller (i.e., user A).

Once the payment vehicle is accepted by the mobile terminal (step **360a**), at step **365a**, transaction component **210** may present a screen where a buyer may enter a PIN for authentication. Notably, transaction component **210** may enable the PIN entry (e.g., by displaying a numeric keypad) only if the monitoring and detection component **215** determines that the person attempting to enter the PIN is different from the seller. In FIG. 3C, the facial image **365b** captured at step **365a** is that of the same person (i.e., the seller, who set up or initiated the electronic payment transaction) compared to the previously-captured facial images **350b**, **355b**, **360b**, indicating that the user device **110** has stayed with the seller (i.e., non-transfer of the user device **110**). Accordingly, the PIN entry may remain disabled until a facial image of the buyer, and only of the buyer, is captured by the image sensor, indicating that the user device **110** has been transferred to the buyer and that there is no one else watching the PIN entry but the buyer. In some embodiments, a hash of the biometrics of individuals using the device **110** may be stored for each transaction in order to detect instances of a third party attempting to enter PINs for a number of different buyers.

Again, although the description provided in relation to the exemplary use cases illustrated in FIGS. 3A-3C only discussed the usage of image data (e.g., facial images captured by an image sensor) to detect suspicious and/or non-suspicious activities, various types of contextual data captured by multiple sensors may be used to more accurately detect suspicious and/or non-suspicious activities. For example, while the act of transferring the user device **110** (or the lack thereof) from a seller (i.e., user A) to a buyer (i.e., user B) for a PIN entry may be inferred from facial images captured at different stages of the electronic payment transaction, additional contextual data may be captured using other sensors to provide more accurate and reliable results. As alluded to above in reference to FIG. 1, user device **110** may contain a number of sensors, which may provide various information about the environment around the user device **110** (i.e., contextual data). For example, a user device **110** may use the following sensors to capture various types of contextual data to detect suspicious and/or non-suspicious activities:

Microphones: User device **110** may include at least two microphones. The microphones used on the device **110** may comprise a telephone microphone and a background noise microphone used for noise cancellation. Some devices may also have more than one microphone in order to record in stereo or surround sound. Each microphone may detect a slightly different sound. As device **110** is moved within an environment, the sounds detected by each microphone may change. If the device **110** is rotated, the sounds measured by the microphones on the device **110** may also appear to rotate. A full 360-degree rotation may, for instance, create an illusion that the sounds will swap from one microphone to the other. By measuring the sound patterns picked up by the multiple microphones, it may be possible to deduce a rotation of the device **110** (e.g., a rotation that might be involved when a mobile terminal is presented to a buyer for a security challenge), a movement of the device **110**, and/or a transfer

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of the device **110** from one location/person to another, based on the changes in sound.

Radio frequency sensors: A number of radio frequencies may be picked up by the user device **110**. These may include Wi-Fi, Bluetooth, Cellular signal, FM radio, etc. A change in these signals can indicate movement. A combination of these signals may be used to create a radio transmission map, which may be used to forensically locate user devices **110**.

Accelerometer, gyroscope & GPS, and magnetometer: A combination of the accelerometer, gyroscope, and magnetometer can be used to detect both the orientation and movement of the user device **110**. A built-in GPS may also be used to determine the location of the device. The accelerometer may measure the vector displacement of a user device **110** in three dimensions in relation to the X, Y and Z axis. The Gyroscope may measure the rotation of a user device **110**, measured around the X, Y and Z axis. The Magnetometer may be a built-in magnetic compass that may be used alongside the gyroscope to calculate a reference in relation to the magnetic north. There may also be a gravity sensor that may be used to identify which way is up. The GPS may be used to determine the longitude and latitude of the user device **110**. In one embodiment, when the user device **110** is moved from one party to another, the combination of the data from the accelerometer, gyroscope, and the magnetometer may be used to represent that movement. Using machine learning, an artificial intelligence (AI) system (e.g., a machine learning model) may gradually be trained to recognize the patterns that relate to a user device **110** being passed from one person to another.

Cameras: The front and back-facing cameras on the user device **110** may be used alongside image recognition to determine movement in different directions. This movement may then be used to deduce relocation or rotation of the device **110**. If an object in the background is identified as a distinct object, then the movement of that object in relation of the user device **110** may be used to determine that the user device **110** is moving. By measuring a number of objects in the environment, the movement of the phone within three dimensional space may be calculated. The autofocus of the camera on the user device **110** may also be used to measure depth of field. If an object believed to be static moves in and out of focus, then it may be deduced that the user device **110** is moving. The cameras may also be used alongside face recognition to help prevent the PIN or security challenge answer from being revealed to a third party.

FIG. 4 is a flowchart illustrating an exemplary method **400** of aggregating contextual data for model building, according to one aspect of the present disclosure. In particular, the steps of method **400** may be performed by the monitoring and detection component **215**. The aggregated contextual data may be used to train a machine learning model in order to identify a suspicious and/or non-suspicious activity. Therefore, the contextual data aggregated in method **400** may also be referred to as "training data."

At step **410**, monitoring and detection component **215** may identify a starting check point. The starting check point defines a point from which one or more appropriate sensors of the user device **110** may capture contextual data. For instance, in the case of an electronic payment transaction (e.g., FIGS. 3A-3C), transaction component **210** may alert the monitoring and detection component **215** to begin cap-

turing contextual data at a particular stage of the electronic payment transaction. For example, transaction component **210** may alert the monitoring and detection component **215** to begin capturing contextual data when a graphical user interface screen for transaction amount entry is displayed (e.g., step **310a** in FIG. **3A**, step **330a** in FIG. **3B**, or step **350A** in FIG. **3C**). In such a case, the point at which the graphical user interface screen for transaction amount entry is displayed may be the starting check point. However, the starting check point may be set at any point during a transaction.

At step **415**, monitoring and detection component **215** may start receiving contextual data from the one or more appropriate sensors of the user device **110**. At step **420**, monitoring and detection component **215** may identify an ending check point. The ending check point defines a point at which the one or more appropriate sensors of the user device **110** may halt capturing contextual data. Notably, the ending check point and the starting check point may be set such that one or more sensors of the user device **110** continue to capture the contextual data when the target activity (i.e., suspicious and/or non-suspicious activity) takes place. For example, in the case of an electronic payment transaction (e.g., FIGS. **3A-3C**), the starting point and the ending point may be set such that the one or more sensors of the user device **110** capture the transfer (or the lack thereof) of the user device **110** from one person to another (e.g., from a seller to a buyer, etc.).

Once the monitoring and detection component **215** identifies the ending check point (step **420**), at step **425**, monitoring and detection component **215** may stop receiving contextual data from the one or more appropriate sensors of the user device **110**, and may transmit the aggregated contextual data to either one of or both the model building component **235** of the training system **120** (to analyze behavior patterns across an entire or a portion of a user base) and the local model building component **245** of the user application **205** (to analyze behavior patterns localized to the user device **110**). For example, in the case of an electronic payment transaction (e.g., FIGS. **3A-3C**), the ending check point may be when the PIN is successfully entered by a payment vehicle owner. However, the ending check point may be set at any suitable point during a transaction.

In another embodiment, monitoring and detection component **215** may start transmitting the contextual data to the model building component as soon as it starts receiving the contextual data from the one or more sensors (i.e., from the starting check point). In other words, instead of waiting until the ending checking point is identified and sending aggregated contextual data to the model building component, monitoring and detection component **215** may transmit the contextual data as they are being captured, during the time period between the starting check point and the ending check point.

FIG. **5** is a flowchart illustrating an exemplary method **500** of training a machine learning model, according to one aspect of the present disclosure. In particular, the steps of method **500** may be performed by either one of or both the model building component **235** and the local model building component **245**. For the sake of brevity, in the following discussion, it will be assumed that the steps of method **500** are performed by the model building component **235**. However, it should be appreciated that the steps of method **500** may also be performed by the local model building component **245**.

At step **510**, model building component **235** may receive contextual data from the user device **110** (or the monitoring

and detection component **215** thereof). At step **515**, model building component **235** may prepare the received contextual data for model training. Data preparation may involve randomizing the ordering of the contextual data, visualizing the contextual data to identify relevant relationships between different variables, identifying any data imbalances, splitting the contextual data into two parts where one part is for training a model and the other part is for validating the trained model, de-duplicating, normalizing, correcting errors in the contextual data, and so on.

Once the contextual data is prepared (step **515**), at step **520**, model building component **235** may train a machine learning model using the prepared contextual data. The trained machine learning model could analyze contextual data associated with a suspicious activity to detect one or more patterns associated with the suspicious activity, and could also analyze contextual data associated with a non-suspicious activity to detect one or more patterns that are associated with the non-suspicious activity. In some embodiments, training of the machine learning model may result in a set of model weights, which can then be used to validate the machine learning model and perform detections via the machine learning model.

At step **525**, model building component **235** may validate the trained machine learning model based on, for example, the model weights generated at step **520**. For example, the machine learning model may be validated by analyzing a set of contextual data that are known to represent a suspicious or a non-suspicious activity. Accordingly, the accuracy of the machine learning model and model weights may be determined. Once the validation step is complete, at step **530**, model building component **235** may store the trained (and validated) machine learning model in a system memory or storage. The trained machine learning model may then be transmitted to and used by the monitoring and detection component **215** of the user device **110** to detect suspicious and/or non-suspicious activities involving device usage.

FIG. **6** is a flowchart illustrating an exemplary method **600** of determining an occurrence of an expected activity (i.e., a non-suspicious activity) using a trained machine learning model, according to one aspect of the present disclosure. In particular, the steps of method **600** may be performed by the monitoring and detection component **215**, and may be performed in contexts described above with reference to FIGS. **3A-3C** (i.e., electronic payment transaction). However, it should be appreciated that the steps of method **600** may be used in any context to which they may be applicable.

At step **610**, monitoring and detection component **215** may identify a starting check point. As alluded to above in reference to step **410** in FIG. **4**, the starting check point defines a point from which one or more appropriate sensors of the user device **110** may capture contextual data. For instance, in the case of an electronic payment transaction (e.g., FIGS. **3A-3C**), transaction component **210** may alert the monitoring and detection component **215** to begin capturing contextual data at a particular stage of the electronic payment transaction. For example, transaction component **210** may alert the monitoring and detection component **215** to begin capturing contextual data when a graphical user interface screen for transaction amount entry is displayed (e.g., step **310a** in FIG. **3A**, step **330a** in FIG. **3B**, or step **350A** in FIG. **3C**). In such a case, the point at which the graphical user interface screen for transaction amount entry is displayed may be the starting check point. However, the starting check point may be set at any point of a transaction.

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At step **615**, monitoring and detection component **215** may start receiving contextual data from the one or more sensors of the user device **110**. Then, at step **620**, monitoring and detection component **215** may determine whether an expected behavior (e.g., transfer of a user device **110** from one user to another, etc.) has occurred based on the received contextual data and a trained machine learning model received from the model training component **235** (or from the local model training component **245**).

At step **625**, if it is determined that an expected behavior occurred within a predetermined time, the method may proceed to step **630** where the monitoring and detection component **215** may present a PIN entry screen or enable PIN entry (or entry of any type of user credentials as discussed above), or may direct transaction component **210** to present the PIN entry screen or enable PIN entry. At this point (step **630**), the monitoring and detection component **215** may also stop receiving contextual data from the one or more sensors (or may direct the one or more sensors to stop transmitting contextual data), as the decision to enable the PIN entry has been made. The point at which to stop receiving contextual data from the one or more sensors may be referred to as an ending check point.

On the other hand, at step **625**, if it is determined that an expected behavior did not occur within a predetermined time, the method may proceed to step **635** where the monitoring and detection component **215** may terminate the transaction, or may direct the transaction component **210** to terminate the transaction. At this point (step **635**), the monitoring and detection component **215** may also stop receiving contextual data from the one or more sensors (or may direct the one or more sensors to stop transmitting contextual data), as the decision to terminate the transaction has been made.

In another embodiment, at step **635**, the monitoring and detection component **215** may cause the user device **110** to display instructions to hand the user device **110** to a buyer (i.e., a payment vehicle owner). In yet another embodiment, at step **635**, the monitoring and detection component **215** may send a notification to the owner of the payment vehicle (e.g., via an email, a text message, an automated phone call, etc.) that a suspicious activity involving the payment vehicle has occurred.

In an alternative embodiment, at step **630**, the monitoring and detection component **215** may keep the PIN entry disabled, and may perform additional authentication processes for added security (e.g., processes described in reference to FIGS. **3A-3C**). For example, the monitoring and detection component **215** may continue to capture one or more facial images of the user facing the user device **110** even after determining that the device transfer has occurred. A facial image captured after determining that the device transfer has occurred may be referred to as a post-transfer facial image. The monitoring and detection component **215** may analyze the post-transfer facial images to determine whether more than one user is staring at the screen of the user device **110**. If it is determined that there are more than one user staring at the screen of the user device **110**, the monitoring and detection component **215** may terminate the transaction or postpone the PIN entry until there is only one person in a subsequently-captured post-transfer facial image. If it is determined that there is just one user staring at the screen of the user device **110**, the monitoring and detection component **215** may either i) enable the PIN entry or ii) proceed with yet another authentication process. For example, the monitoring and detection component **215** may compare the one or more post-transfer facial images to the

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one or more facial images that are captured prior to determining that the device transfer has occurred (i.e., pre-transfer facial images). If it is determined that the face recognized in the post-transfer facial images is different from the face recognized in the pre-transfer facial images, the monitoring and detection component **215** may present a PIN entry screen or enable PIN entry.

At this point, the monitoring and detection component **215** may also stop receiving contextual data from the one or more sensors (or may direct the one or more sensors to stop transmitting contextual data), as the decision to enable the PIN entry has been made. If it is determined that the face recognized in the post-transfer facial images is the same as the face recognized in the pre-transfer images, the monitoring and detection component **215** may terminate the transaction, as discussed above. At this point, the monitoring and detection component **215** may also stop receiving contextual data from the one or more sensors (or may direct the one or more sensors to stop transmitting contextual data), as the decision to terminate the transaction has been made.

As alluded to above, in one embodiment, user application **205** may be a device security application. For example, a device security application may enable a user to unlock the user device **110** using a facial recognition technology. FIG. **7A** is an exemplary user case diagram illustrating graphical user interface screens of the user application **205** (i.e., device security application that enables locking/unlocking of the user device **110**) and the contextual data captured at different stages of the unlock procedure. Similar to FIGS. **3A-3C**, FIG. **7A** also illustrates a context in which the embodiments contemplated by the present disclosure may be applied.

Transaction component **210** of the user application **205** may present graphical user interface screens to walk a user through one or more facial recognition steps to unlock the user device **110**. At step **710a**, the user device **110** is “locked” and the lock screen is displayed. If a user wishes to “unlock” the user device **110**, the user may touch or swipe the lock screen to enter a “unlock” stage (i.e., facial recognition stage). At step **715a**, in response to a user touching or swiping the lock screen, transaction component **210** may present a screen indicating that the facial recognition is being initiated. For example, the screen may show a polygon-shaped or circular-shaped box through which a facial image being captured by the user device **110** may be shown. The screen may direct or steer the user to adjust the position of user device **110** relative to the face, such that the entire face is shown through the box, in order to unlock the user device **110**.

While the transaction component **210** may display graphical user interface screens to walk a user through the “unlock” stage (i.e., facial recognition stage), monitoring and detection component **215** may collect contextual data using sensors of the user device **110**, to identify suspicious and/or non-suspicious activities that might be associated with the unlock procedure. In one embodiment, monitoring and detection component **215** may direct an image sensor of the user device **110** (i.e., camera) to capture a facial image of the person attempting to unlock the device. For example, as shown in FIG. **7A**, facial images of the person using the device **110** or facing the screen of the device **110** (e.g., **710b**, **715b**) may be captured at different stages of the unlock procedure. For example, facial image **710b** may be captured at step **710a** (i.e., when a user looks at the lock screen or swipes/touches the lock screen) and/or facial image **715b** may be captured at step **715a** (i.e., when a user is presented with a screen indicating that facial recognition is being initiated/performed). The monitoring and detection compo-

ment **215** may compare the captured facial images with one or more facial images of the persons authorized to use the device, which may have been previously saved in the user device **110**. At step **720a**, in response to the monitoring and detection component **215** determining that the captured facial image matches one of the facial images of the authorized persons, the user device **110** may be unlocked and the user may be presented with a home screen.

During the unlock procedure, monitoring and detection component **215** may also direct other sensors of the user device **110** (i.e., sensors other than the image sensor capturing facial images) to capture additional contextual data during the unlock procedure, to identify any suspicious activities which may not be detectable solely by capturing and analyzing facial images. For example, an unauthorized user may take or steal the user device **110** from an authorized user, swipe or touch the lock screen, and hold the user device **110** in front of the authorized user's face to unlock the device. Detecting suspicious activities of this type may require more than just capturing the facial images of the persons facing the device.

FIG. 7B is another exemplary use case diagram illustrating graphical user interface screens of the user application **205** (i.e., device security application that locks/unlocks the user device **110**) and the contextual data captured at different stages of the unlock procedure. FIG. 7B also illustrates a context in which the embodiments contemplated by the present disclosure may be applied. Notably, FIG. 7B illustrates a scenario where detection of a suspicious activity may require using multiple sensors of the user device **110**.

At step **725a**, the user device **110** is "locked" and the lock screen is displayed. If a user wishes to "unlock" the user device **110**, the user may touch or swipe the lock screen to enter a "unlock" stage (i.e., facial recognition stage). At step **730a**, in response to a user touching or swiping the lock screen, transaction component **210** may present a screen indicating that the facial recognition is being initiated. For example, the screen may show a polygon-shaped or circular-shaped box through which a facial image being captured by the user device **110** is shown. The screen may direct or steer the user to adjust the position of user device **110** relative to the face, such that the entire face may be shown through the box, in order to unlock the device **110**.

As alluded to above, if the person facing the device screen and attempting to unlock the user device **110** is an unauthorized user, the user device **110** may remain locked because the facial image of the user does not match any of the stored facial images of authorized users. However, the unauthorized user may still attempt to unlock the user device **110** by holding the user device **110** in front of an authorized user's face. For example, at step **735a**, the unauthorized user may hold the user device **110** in front of an authorized user's face and may "shake" or "wave" the device **110** such that the entire face of the authorized user may be captured at the designated location (i.e., within the box as shown in **735b**). If only facial images were used to detect suspicious activities, this behavior (i.e., an unauthorized user "shaking" or "waving" the device **110** in front of the authorized user's face) could go undetected and the device **110** may be unlocked.

Accordingly, a number of sensors may be used for detection. In one embodiment, the movement pattern of "shaking" or "waving" the device **110** in front of an authorized user (i.e., a victim) in conjunction with multiple facial images captured at different stages of the unlocking operation may be used to determine that a suspicious activity is taking place. As discussed above, one or more of global positioning

system (GPS) sensors, vision sensors (i.e., cameras), audio sensors (i.e., microphones), light sensors, temperature sensors, radio frequency sensors, direction sensors (i.e., magnetic compasses, magnetometers, gyroscopes), and acceleration sensors (i.e., accelerometers) in the user device **110** may be used to capture contextual data representative of the movement of the device **110** as well as the biometric measurements (e.g., facial images).

With continuing reference to FIG. 7B, using the contextual data collected by various sensors of the user device **110**, at step **740a**, monitoring and detection component **215** may determine that a suspicious activity is taking place and may keep the user device **110** locked. In some embodiments, the step of keeping the user device **110** locked may involve notifying the transaction component **210** of the fraudulent login or unlock attempt, such that the transaction component **210** may keep the device locked **110** and may display the lock screen.

FIG. 8 is a flowchart illustrating an exemplary method **800** of determining an occurrence of a suspicious activity using a trained machine learning model, according to one aspect of the present disclosure. In particular, the steps of method **800** may be performed by the monitoring and detection component **215**, and may be performed in contexts described above with reference to FIGS. 7A-7B (i.e., unlock procedure). However, it should be appreciated that the steps of method **800** may be used in any context to which they may be applicable. Further, methods **400** and **500** of aggregating contextual data representing a target activity and training a machine learning model based on the aggregated contextual data, respectively, may also be used in conjunction with method **800**, to determine a target activity discussed below with reference to FIG. 8 (i.e., "shaking" or "waving" user device **110** in front of a victim's face).

At step **810**, monitoring and detection component **215** may identify a starting check point. As alluded to above in reference to step **410** in FIG. 4, the starting check point defines a point from which one or more appropriate sensors of the user device **110** may capture contextual data. For instance, in the case of an unlock procedure (e.g., FIGS. 7A-7B), transaction component **210** may alert the monitoring and detection component **215** to begin capturing contextual data at a particular stage of the unlock procedure. For example, transaction component **210** may alert the monitoring and detection component **215** to begin capturing contextual data when a user touches or swipes the lock screen to initiate the unlock process (e.g., step **710a** in FIG. 7A, or step **725a** in FIG. 7B). In such a case, the point at which the user touches or swipes the lock screen may be the starting check point. However, the starting check point may be set at any point during the unlock procedure. At step **815**, monitoring and detection component **215** may start receiving contextual data from the one or more sensors of the user device **110**. Then, at step **820**, monitoring and detection component **215** may determine whether a suspicious activity (e.g., a user "shaking" or "waving" of the user device **110** in front of another user) has occurred based on the received contextual data and a trained machine learning model received from the model training component **235** (or from the local model training component **245**). At step **825**, if it is determined that a suspicious activity occurred or a predetermined time has passed since the unlock process was initiated, the method may proceed to step **830** where the monitoring and detection component **215** may keep the device **110** locked and display the lock screen (or directs the transaction component **210** to keep the device **110** locked and to display the lock screen), even if the facial image

captured during the unlock stage matches that of an authorized user. At this point (step 830), the monitoring and detection component 215 may also stop receiving contextual data from the one or more sensors (or may direct the one or more sensors to stop transmitting contextual data), as the decision to keep the device locked has been made. On the other hand, at step 825, if it is determined that a suspicious activity did not occur (e.g., no “shaking” or “waiving” of the device 110 in front of an authorized user, and the facial image captured during the unlock stage matches that of an authorized user) and a predetermined time has not passed since the unlock process was initiated, the method may proceed to step 835 where the monitoring and detection component 215 may unlock the device 110 and display the home screen (or directs the transaction component 210 to unlock the device 110 and to display the home screen). At this point (step 835), the monitoring and detection component 215 may also stop receiving contextual data from the one or more sensors (or may direct the one or more sensors to stop transmitting contextual data), as the decision to unlock the device 110 has been made. In another embodiment, at step 830, in addition to keeping the device 110 locked, the monitoring and detection component 215 may send a notification to the owner(s) of the user device 110 (e.g., via an email, a text message, an automated phone call, etc.) that a fraudulent login/unlock attempt has taken place.

It should be appreciated that the use cases illustrated in FIGS. 3A-3C and 7A-7B are merely exemplary, and the embodiments contemplated by the present disclosure may also be applicable to variations of the use cases specifically discussed herein. For example, other use cases may include, but may not be limited to:

Learning the pattern of a mobile QR code ticket being shown to a ticket inspector on a train.

The pattern of movement to present a loyalty QR code to a QR code reader in a store.

The pattern of movement made when tapping a mobile phone onto a contactless reader for payments or for transit.

Combining the movements of two devices to indicate that they were both being moved together for a synchronized process such as a phone to phone payment, or near-field data exchange between two phones.

The embodiments of the present disclosure may be adjusted or modified to encompass varying use case scenarios. For example, with reference to FIGS. 3A-3C, while the buyer’s facial image captured at the payment vehicle provision confirmation step (e.g., steps 320a, 340a, 360a) may be considered non-suspicious in the United States of America, the same may not be true for electronic payment transactions occurring in a different country. For example, certain countries may have laws in place that require a mobile terminal to be transferred/presented to the buyer when the payment vehicle is provided (i.e., “swiped” or “tapped”) by the buyer. In such a case, the starting check point and the ending check point discussed in reference to FIGS. 4 and 6 may be adjusted in order to capture the contextual data indicative of the transfer (or the lack thereof), which is supposed to occur at a point after the transaction amount entry (e.g., steps 310a, 330a, 350a) but before the payment vehicle provision confirmation (e.g., steps 320a, 340a, 360a).

Unless specifically stated otherwise, as apparent from the following discussions, it is appreciated that throughout the specification discussions utilizing terms such as “processing,” “computing,” “calculating,” “determining,” “analyzing” or the like, refer to the action and/or processes of a

computer or computing system, or similar electronic computing device, that manipulate and/or transform data represented as physical, such as electronic, quantities into other data similarly represented as physical quantities.

In a similar manner, the term “processor” may refer to any device or portion of a device that processes electronic data, e.g., from registers and/or memory to transform that electronic data into other electronic data that, e.g., may be stored in registers and/or memory. A “computer,” a “computing machine,” a “computing platform,” a “computing device,” or a “server” may include one or more processors.

FIG. 9 illustrates an implementation of a general computer system designated 900. The computer system 900 can include a set of instructions that can be executed to cause the computer system 900 to perform any one or more of the methods or computer based functions disclosed herein. The computer system 900 may operate as a standalone device or may be connected, e.g., using a network, to other computer systems or peripheral devices.

In a networked deployment, the computer system 900 may operate in the capacity of a server or as a client user computer in a server-client user network environment, or as a peer computer system in a peer-to-peer (or distributed) network environment. The computer system 900 can also be implemented as or incorporated into various devices, such as a personal computer (PC), a tablet PC, a set-top box (STB), a personal digital assistant (PDA), a mobile device, a palmtop computer, a laptop computer, a desktop computer, a communications device, a wireless telephone, a land-line telephone, a control system, a camera, a scanner, a facsimile machine, a printer, a pager, a personal trusted device, a web appliance, a network router, switch or bridge, or any other machine capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that machine. In a particular implementation, the computer system 900 can be implemented using electronic devices that provide voice, video, or data communication. Further, while a single computer system 900 is illustrated, the term “system” shall also be taken to include any collection of systems or sub-systems that individually or jointly execute a set, or multiple sets, of instructions to perform one or more computer functions.

As illustrated in FIG. 9, the computer system 900 may include a processor 902, e.g., a central processing unit (CPU), a graphics processing unit (GPU), or both. The processor 902 may be a component in a variety of systems. For example, the processor 902 may be part of a standard personal computer or a workstation. The processor 902 may be one or more general processors, digital signal processors, application specific integrated circuits, field programmable gate arrays, servers, networks, digital circuits, analog circuits, combinations thereof, or other now known or later developed devices for analyzing and processing data. The processor 902 may implement a software program, such as code generated manually (i.e., programmed).

The computer system 900 may include a memory 904 that can communicate via a bus 908. The memory 904 may be a main memory, a static memory, or a dynamic memory. The memory 904 may include, but is not limited to computer readable storage media such as various types of volatile and non-volatile storage media, including but not limited to random access memory, read-only memory, programmable read-only memory, electrically programmable read-only memory, electrically erasable read-only memory, flash memory, magnetic tape or disk, optical media and the like. In one implementation, the memory 904 includes a cache or random-access memory for the processor 902. In alternative

implementations, the memory **904** is separate from the processor **902**, such as a cache memory of a processor, the system memory, or other memory. The memory **904** may be an external storage device or database for storing data. Examples include a hard drive, compact disc (“CD”), digital video disc (“DVD”), memory card, memory stick, floppy disc, universal serial bus (“USB”) memory device, or any other device operative to store data. The memory **904** is operable to store instructions executable by the processor **902**. The functions, acts or tasks illustrated in the figures or described herein may be performed by the programmed processor **902** executing the instructions stored in the memory **904**. The functions, acts or tasks are independent of the particular type of instructions set, storage media, processor or processing strategy and may be performed by software, hardware, integrated circuits, firm-ware, micro-code and the like, operating alone or in combination. Likewise, processing strategies may include multiprocessing, multitasking, parallel processing and the like.

As shown, the computer system **900** may further include a display unit **910**, such as a liquid crystal display (LCD), an organic light emitting diode (OLED), a flat panel display, a solid-state display, a cathode ray tube (CRT), a projector, a printer or other now known or later developed display device for outputting determined information. The display **910** may act as an interface for the user to see the functioning of the processor **902**, or specifically as an interface with the software stored in the memory **904** or in the drive unit **906**.

Additionally or alternatively, the computer system **900** may include an input device **912** configured to allow a user to interact with any of the components of system **900**. The input device **912** may be a number pad, a keyboard, or a cursor control device, such as a mouse, or a joystick, touch screen display, remote control, or any other device operative to interact with the computer system **900**.

The computer system **900** may also or alternatively include a disk or optical drive unit **906**. The disk drive unit **906** may include a computer-readable medium **922** in which one or more sets of instructions **924**, e.g. software, can be embedded. Further, the instructions **924** may embody one or more of the methods or logic as described herein. The instructions **924** may reside completely or partially within the memory **904** and/or within the processor **902** during execution by the computer system **900**. The memory **904** and the processor **902** also may include computer-readable media as discussed above.

In some systems, a computer-readable medium **922** includes instructions **924** or receives and executes instructions **924** responsive to a propagated signal so that a device connected to a network **105** can communicate voice, video, audio, images, or any other data over the network **105**. Further, the instructions **924** may be transmitted or received over the network **105** via a communication port or interface **920**, and/or using a bus **908**. The communication port or interface **920** may be a part of the processor **902** or may be a separate component. The communication port **920** may be created in software or may be a physical connection in hardware. The communication port **920** may be configured to connect with a network **105**, external media, the display **910**, or any other components in system **900**, or combinations thereof. The connection with the network **105** may be a physical connection, such as a wired Ethernet connection or may be established wirelessly as discussed below. Likewise, the additional connections with other components of the system **900** may be physical connections or may be established wirelessly. The network **105** may alternatively be directly connected to the bus **908**.

While the computer-readable medium **922** is shown to be a single medium, the term “computer-readable medium” may include a single medium or multiple media, such as a centralized or distributed database, and/or associated caches and servers that store one or more sets of instructions. The term “computer-readable medium” may also include any medium that is capable of storing, encoding, or carrying a set of instructions for execution by a processor or that cause a computer system to perform any one or more of the methods or operations disclosed herein. The computer-readable medium **922** may be non-transitory, and may be tangible.

The computer-readable medium **922** can include a solid-state memory such as a memory card or other package that houses one or more non-volatile read-only memories. The computer-readable medium **922** can be a random-access memory or other volatile re-writable memory. Additionally or alternatively, the computer-readable medium **922** can include a magneto-optical or optical medium, such as a disk or tapes or other storage device to capture carrier wave signals such as a signal communicated over a transmission medium. A digital file attachment to an e-mail or other self-contained information archive or set of archives may be considered a distribution medium that is a tangible storage medium. Accordingly, the disclosure is considered to include any one or more of a computer-readable medium or a distribution medium and other equivalents and successor media, in which data or instructions may be stored.

In an alternative implementation, dedicated hardware implementations, such as application specific integrated circuits, programmable logic arrays and other hardware devices, can be constructed to implement one or more of the methods described herein. Applications that may include the apparatus and systems of various implementations can broadly include a variety of electronic and computer systems. One or more implementations described herein may implement functions using two or more specific interconnected hardware modules or devices with related control and data signals that can be communicated between and through the modules, or as portions of an application-specific integrated circuit. Accordingly, the present system encompasses software, firmware, and hardware implementations.

The computer system **900** may be connected to one or more networks **10026**. The network **105** may define one or more networks including wired or wireless networks. The wireless network may be a cellular telephone network, an 802.11, 802.16, 802.20, or WiMax network. Further, such networks may include a public network, such as the Internet, a private network, such as an intranet, or combinations thereof, and may utilize a variety of networking protocols now available or later developed including, but not limited to TCP/IP based networking protocols. The network **105** may include wide area networks (WAN), such as the Internet, local area networks (LAN), campus area networks, metropolitan area networks, a direct connection such as through a Universal Serial Bus (USB) port, or any other networks that may allow for data communication. The network **105** may be configured to couple one computing device to another computing device to enable communication of data between the devices. The network **105** may generally be enabled to employ any form of machine-readable media for communicating information from one device to another. The network **105** may include communication methods by which information may travel between computing devices. The network **105** may be divided into sub-networks. The sub-networks may allow access to all of the other components connected thereto or the sub-networks may restrict access between the components. The network

105 may be regarded as a public or private network connection and may include, for example, a virtual private network or an encryption or other security mechanism employed over the public Internet, or the like.

In accordance with various implementations of the present disclosure, the methods described herein may be implemented by software programs executable by a computer system. Further, in an exemplary, non-limited implementation, implementations can include distributed processing, component/object distributed processing, and parallel processing. Alternatively, virtual computer system processing can be constructed to implement one or more of the methods or functionality as described herein.

Although the present specification describes components and functions that may be implemented in particular implementations with reference to particular standards and protocols, the disclosure is not limited to such standards and protocols. For example, standards for Internet and other packet switched network transmission (e.g., TCP/IP, UDP/IP, HTML, HTTP) represent examples of the state of the art. Such standards are periodically superseded by faster or more efficient equivalents having essentially the same functions. Accordingly, replacement standards and protocols having the same or similar functions as those disclosed herein are considered equivalents thereof.

It will be understood that the steps of methods discussed are performed in one embodiment by an appropriate processor (or processors) of a processing (i.e., computer) system executing instructions (computer-readable code) stored in storage. It will also be understood that the invention is not limited to any particular implementation or programming technique and that the invention may be implemented using any appropriate techniques for implementing the functionality described herein. The invention is not limited to any particular programming language or operating system.

It should be appreciated that in the above description of exemplary embodiments of the invention, various features of the invention are sometimes grouped together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of one or more of the various inventive aspects. This method of disclosure, however, is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the claims following the Detailed Description are hereby expressly incorporated into this Detailed Description, with each claim standing on its own as a separate embodiment of this invention.

Furthermore, while some embodiments described herein include some but not other features included in other embodiments, combinations of features of different embodiments are meant to be within the scope of the invention, and form different embodiments, as would be understood by those skilled in the art. For example, in the following claims, any of the claimed embodiments can be used in any combination.

Furthermore, some of the embodiments are described herein as a method or combination of elements of a method that can be implemented by a processor of a computer system or by other means of carrying out the function. Thus, a processor with the necessary instructions for carrying out such a method or element of a method forms a means for carrying out the method or element of a method. Furthermore, an element described herein of an apparatus embodi-

ment is an example of a means for carrying out the function performed by the element for the purpose of carrying out the invention.

In the description provided herein, numerous specific details are set forth. However, it is understood that embodiments of the invention may be practiced without these specific details. In other instances, well-known methods, structures and techniques have not been shown in detail in order not to obscure an understanding of this description.

Similarly, it is to be noticed that the term coupled, when used in the claims, should not be interpreted as being limited to direct connections only. The terms “coupled” and “connected,” along with their derivatives, may be used. It should be understood that these terms are not intended as synonyms for each other. Thus, the scope of the expression a device A coupled to a device B should not be limited to devices or systems wherein an output of device A is directly connected to an input of device B. It means that there exists a path between an output of A and an input of B which may be a path including other devices or means. “Coupled” may mean that two or more elements are either in direct physical or electrical contact, or that two or more elements are not in direct contact with each other but yet still co-operate or interact with each other.

Thus, while there has been described what are believed to be the preferred embodiments of the invention, those skilled in the art will recognize that other and further modifications may be made thereto without departing from the spirit of the invention, and it is intended to claim all such changes and modifications as falling within the scope of the invention. For example, any formulas given above are merely representative of procedures that may be used. Functionality may be added or deleted from the block diagrams and operations may be interchanged among functional blocks. Steps may be added or deleted to methods described within the scope of the present invention.

The above disclosed subject matter is to be considered illustrative, and not restrictive, and the appended claims are intended to cover all such modifications, enhancements, and other implementations, which fall within the true spirit and scope of the present disclosure. Thus, to the maximum extent allowed by law, the scope of the present disclosure is to be determined by the broadest permissible interpretation of the following claims and their equivalents, and shall not be restricted or limited by the foregoing detailed description. While various implementations of the disclosure have been described, it will be apparent to those of ordinary skill in the art that many more implementations and implementations are possible within the scope of the disclosure. Accordingly, the disclosure is not to be restricted except in light of the attached claims and their equivalents.

What is claimed is:

1. A computer-implemented method of detecting a suspicious activity and/or a non-suspicious activity during an electronic transaction performed by a user device, comprising:

receiving, by a model building component, sample contextual data from one or more sensors of a plurality of user devices;

training, by the model building component using the sample contextual data, a machine learning model to identify suspicious and/or non-suspicious activities;

receiving, by a monitoring and detection component, contextual data from the one or more sensors of the plurality of user devices;

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determining, by the monitoring and detection component and using the trained machine learning model, whether an expected behavior occurred; and

in response to determining that the expected behavior occurred:

determining, by the monitoring and detection component, a facial image in the contextual data upon determining a device transfer has occurred; and

in response to determining a post device transfer facial image is different from a pre device transfer facial image, enabling, by the monitoring and detection component, entry of user credentials, wherein the entry of the user credentials is disabled upon determining more than one users are staring at the screen of the user device at a credentials entry stage.

2. The method of claim 1, wherein the sample contextual data comprises at least one or more of: i) vector displacement measurements received from an accelerometer of each of the plurality of user devices, ii) rotation measurements received from a gyroscope and a magnetometer of each of the plurality of user devices, iii) sound measurements received from one or more microphones of each of the plurality of user devices, or iv) image data received from one or more cameras of each of the plurality of user devices.

3. The method of claim 1, wherein the contextual data further comprises at least one or more of: i) vector displacement measurements received from an accelerometer of the user device, ii) rotation measurements received from a gyroscope and a magnetometer of the user device, iii) sound measurements received from one or more microphones of the user device, or iv) image data received from one or more cameras of the user device.

4. The method of claim 1, wherein the electronic transaction is terminated in response to determining the expected behavior not occurring within a predetermined amount of time.

5. The method of claim 1, wherein the contextual data further comprises a pre-transfer facial image and a post-transfer facial image, further comprising:

in response to determining an occurrence of the expected behavior:

determining, by the monitoring and detection component, whether a first face detected in the pre-transfer facial image is different from a second face detected in the post-transfer facial image; and

in response to determining that the first face is different from the second face, enabling, by the monitoring and detection component, entry of user credentials; or

in response to determining that the first face matches the second face, disabling, by the monitoring and detection component, entry of user credentials.

6. The method of claim 1, further comprising: identifying, by the monitoring and detection component, a starting check point in the electronic transaction using the user device,

wherein the monitoring and detection component directs the one or more sensors of the plurality of user devices to begin transmitting the contextual data at the starting check point.

7. The method of claim 6, further comprising: identifying, by the monitoring and detection component, an ending check point in the electronic transaction using the user device,

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wherein the monitoring and detection component directs the one or more sensors of the plurality of user devices to halt transmitting the contextual data at the ending check point.

8. A system for detecting a suspicious activity and/or a non-suspicious activity during an electronic transaction performed by a user device, comprising:

one or more processors;

a non-transitory computer readable medium storing instructions which, when executed by the one or more processors, cause the one or more processors to perform a method comprising:

receiving, by a model building component, sample contextual data from one or more sensors of a plurality of user devices;

training, by the model building component using the sample contextual data, a machine learning model to identify suspicious and/or non-suspicious activities;

receiving, by a monitoring and detection component, contextual data from the one or more sensors of the plurality of user devices;

determining, by the monitoring and detection component and using the trained machine learning model, whether an expected behavior occurred; and

in response to determining that the expected behavior occurred:

determining, by the monitoring and detection component, a facial image in the contextual data upon determining a device transfer has occurred; and

in response to determining a post device transfer facial image is different from a pre device transfer facial image, enabling, by the monitoring and detection component, entry of user credentials, wherein the entry of the user credentials is disabled upon determining more than one users are staring at the screen of the user device at a credentials entry stage.

9. The system of claim 8, wherein the sample contextual data comprises at least one or more of: i) vector displacement measurements received from an accelerometer of each of the plurality of user devices, ii) rotation measurements received from a gyroscope and a magnetometer of each of the plurality of user devices, iii) sound measurements received from one or more microphones of each of the plurality of user devices, or iv) image data received from one or more cameras of each of the plurality of user devices.

10. The system of claim 8, wherein the contextual data further comprises at least one or more of: i) vector displacement measurements received from an accelerometer of the user device, ii) rotation measurements received from a gyroscope and a magnetometer of the user device, iii) sound measurements received from one or more microphones of the user device, or iv) image data received from one or more cameras of the user device.

11. The system of claim 8, wherein the electronic transaction is terminated in response to determining the expected behavior not occurring within a predetermined amount of time.

12. The system of claim 8, wherein the contextual data further comprises a pre-transfer facial image and a post-transfer facial image and the method further comprises:

in response to determining an occurrence of the expected behavior:

determining, by the monitoring and detection component, whether a first face detected in the pre-transfer facial image is different from a second face detected in the post-transfer facial image; and

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in response to determining that the first face is different from the second face, enabling, by the monitoring and detection component, entry of user credentials; or

in response to determining that the first face matches the second face, disabling, by the monitoring and detection component, entry of user credentials.

13. The system of claim **8**, wherein the method further comprises:

identifying, by the monitoring and detection component, a starting check point in the electronic transaction using the user device,

wherein the monitoring and detection component directs the one or more sensors of the plurality of user devices to begin transmitting the contextual data at the starting check point.

14. The system of claim **13**, wherein the method further comprises:

identifying, by the monitoring and detection component, an ending check point in the electronic transaction using the user device,

wherein the monitoring and detection component directs the one or more sensors of the plurality of user devices to halt transmitting the contextual data at the ending check point.

15. A non-transitory computer readable medium storing instructions that, when executed by one or more processors, cause the one or more processors to perform a method of detecting a suspicious activity and/or a non-suspicious activity during an electronic transaction performed by a user device, the method comprising:

receiving, by a model building component, sample contextual data from one or more sensors of a plurality of user devices;

training, by the model building component using the sample contextual data, a machine learning model to identify suspicious and/or non-suspicious activities;

receiving, by a monitoring and detection component, contextual data from the one or more sensors of the plurality of user devices;

determining, by the monitoring and detection component and using the trained machine learning model, whether an expected behavior occurred; and

in response to determining that the expected behavior occurred:

determining, by the monitoring and detection component, a facial image in the contextual data upon determining a device transfer has occurred; and

in response to determining a post device transfer facial image is different from a pre device transfer facial image, enabling, by the monitoring and detection component, entry of user credentials, wherein the entry of the user credentials is disabled upon determining more than one users are staring at the screen of the user device at a credentials entry stage.

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16. The non-transitory computer readable medium of claim **15**, wherein the sample contextual data comprises at least one or more of: i) vector displacement measurements received from an accelerometer of each of the plurality of user devices, ii) rotation measurements received from a gyroscope and a magnetometer of each of the plurality of user devices, iii) sound measurements received from one or more microphones of each of the plurality of user devices, or iv) image data received from one or more cameras of each of the plurality of user devices.

17. The non-transitory computer readable medium of claim **15**, wherein the contextual data further comprises at least one or more of: i) vector displacement measurements received from an accelerometer of the user device, ii) rotation measurements received from a gyroscope and a magnetometer of the user device, iii) sound measurements received from one or more microphones of the user device, or iv) image data received from one or more cameras of the user device.

18. The non-transitory computer readable medium of claim **15**, wherein the electronic transaction is terminated in response to determining the expected behavior not occurring within a predetermined amount of time.

19. The non-transitory computer readable medium of claim **15**, wherein the contextual data further comprises a pre-transfer facial image and a post-transfer facial image and the method further comprises:

in response to determining an occurrence of the expected behavior:

determining, by the monitoring and detection component, whether a first face detected in the pre-transfer facial image is different from a second face detected in the post-transfer facial image; and

in response to determining that the first face is different from the second face, enabling, by the monitoring and detection component, entry of user credentials; or

in response to determining that the first face matches the second face, disabling, by the monitoring and detection component, entry of user credentials.

20. The non-transitory computer readable medium of claim **15**, wherein the method further comprises:

identifying, by the monitoring and detection component, a starting check point in an electronic transaction using the user device, the monitoring and detection component directing the one or more sensors of the plurality of user devices to begin transmitting the contextual data at the starting check point; and

identifying, by the monitoring and detection component, an ending check point in the electronic transaction using the user device, the monitoring and detection component directing the one or more sensors of the plurality of user devices to halt transmitting the contextual data at the ending check point.

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